THE ENGINEER

DECEMBER 12, 1952

The Rearmament Programme

A STATEMENT of the United Kingdom's defence production programme was made in the House of Commons on Thursday of last week by the Prime Minister, Mr. Winston Churchill. In the course of it, Mr. Churchill said that, if the three-year rearmament programme drawn up by the last Government had been carried through in full, expenditure on defence at end-1951 prices would, in the current financial year, have been over £1650 million, and would have risen in 1953 to more than £1800 million. Within those totals, expenditure on production would have been over £725,000,000 this year and over £850,000,000 next year. Moreover, much of that increased burden would have fallen on the engineering industry on which the country depended so much for the vitally needed expansion of its export trade. In the light of those considerations, the Prime Minister continued, the Government had come to the conclusion that any substantial rise above this year's high level of expenditure on defence production must be prevented. Some curtailment must therefore be made which would to some extent involve the cancellation or modification of contracts already placed. The reductions, the Prime Minister went on to say, would be brought about, as far as possible, by spreading deliveries of equipment over a longer period. The effect would be to prevent further increases in the amount of labour and materials used for defence production rather than to reduce the total of those resources now devoted to the purpose. But it would not be possible, however, to solve the problem entirely by spreading deliveries forward into future months or years. That, the Prime Minister said, applied in particular to aircraft. The production of designs now in service would be reduced somewhat, but the introduction of newer and still more advanced aircraft would be pressed forward as rapidly as possible. Moreover, in view of the progress which had taken place in the medium bomber, it was possible to curtail to some extent earlier plans for re-equipment with light bombers.

The Aircraft Industry and Defence Production

FOLLOWING the Prime Minister's statement on defence production—referred to in the preceding note—the Minister of Supply, Mr. Duncan Sandys, met representatives of the aircraft industries to discuss with them the detailed effects of the changes in the defence production programme. Mr. Sandys explained that although the curve of aircraft production would rise less steeply than had been previously planned, the output of military aircraft would continue to expand. He said that the labour force engaged on defence work in the aircraft industry was expected to rise by some 10,000 during the next twelve months. In addition there would be a further increase in employment on the civil side as a result of the growing demand throughout the world for British airliners, such as the "Comet," the "Viscount," and the "Britannia." The changes in the defence programme might create temporary redundancies in two or three firms amounting altogether to about 2500 out of a total of over 200,000 employed in the industry. The changes in the programme had been dictated by the necessity to prevent expenditure climbing beyond the limits of the country's financial capacity. The Minister emphasised that decisions to reduce orders for this or that aircraft reflected in no way whatsoever upon its technical or operational qualities. This was particularly true in the case of the "Canberra," which was the first of the super-priority classes to be brought into service. It was not only being produced as a light bomber for the Royal Air Force, but was also being manufactured in the U.S.A. under licence to fulfil the intruder role. The "Canberra" would, of course, continue to be accorded super-priority, as would also the other outstanding new aircraft—the "Hunter," the "Swift," the "Javelin," the "Valiant," and the "Gannet." These advanced aircraft would now account for a considerably larger proportion of the total programme. The fact that the numbers of the other aircraft were being reduced made it more than ever urgent to speed production of the six super-priority classes and to ensure punctual delivery to the services.

Merchant Shipping Replacement

ON Friday of last week, in the House of Commons, on the motion for adjournment, Commander R. Scott-Miller, member for King's Lynn, brought to the notice of the House the increasing difficulties in the maintenance and replacement of the Merchant Navy. He emphasised that the mercantile marine had become the fourth arm of defence and that all rearmament measures would be impotent if our merchant shipping was allowed to decline. The tonnage sunk during the war had been replaced by the efforts of the shipbuilding industry and largely financed by the shipping companies, since the war-risk insurance scheme fell a long way short of requirements. Commander Scott-Miller said that an industry which contributed about £150 million towards our invisible exports was of paramount importance and he pointed out that to-day we owned one-fifth of the world's tonnage, whereas in 1905 the figure was one-half. Another matter of concern was the age of the dry cargo fleet, one-third of the ships were more than fifteen years old and a quarter more than twenty years old, while more than 40 per cent of the home trade vessels were more than twenty years old. High costs of new ships made them almost an uneconomical proposition to run and the Commander said that shipping could not be protected in the home market, it had to face keen international competition and was concerned with the hampering effects of taxation in the matter of ship replacement, since a ship has to be replaced as a whole and large sums of money were involved. The member for King's Lynn urged that the problem was vital and could not await the report of the Royal Commission and asked for an interim report to assist the Council of Shipping. Mr. John Boyd-Carpenter, the Financial Secretary to the Treasury, replying, dealt with the tonnage figures and the question of the age of shipping and then pointed out that British shipyards had four years' work in hand.

Institution of Water Engineers

THE fifty-seventh winter general meeting of the Institution of Water Engineers was held on Friday last, December 5th, at the Institution of Civil Engineers, Great George Street, London, S.W.1, with the president, Mr. K. L. Forster, in the chair. Apart from the usual formal business, four papers were presented, in which a number of interesting problems were discussed. One of the papers—"The Harrogate Dam Failure"—is reproduced in abstract on another page of this issue; the other three were entitled "Prestressed Concrete Dams and Tanks," by Professor R. H. Evans, "The Analytical Approach to Seepage and Stability Problems," by K. L. Nash, and "Graphical Analysis of Pressure-Surge in Pumping Systems," by H. R. Lupton. The author of the last-named paper pointed out that his aim was to recapitulate briefly the graphical methods most useful in dealing with surge problems in pumping systems, and then to give illustrations of their practical application in typical instances; purely mathematical, as opposed to graphical methods, were not dealt with. An account of the theoretical principles underlying the study of the soil mechanics of seepage and stability was given by Mr. Nash in his paper. The use of prestressing with vertical cables embedded in the formation under a dam or with flat jacks used to induce compressive stresses in the toe of a dam (the methods of Coyne and Freyssinet, respectively) were described by Professor Evans, who gave examples of the use of prestressing for works involving enlarging or repairing dams. He also described the use of prestressed concrete for service reservoirs and circular tanks, and his paper included examples of various new kinds of designs for dams which the prestressing technique makes possible, some of which are to be built in the near future.

Annual Report of the Metropolitan Water Board

THE annual report of the Metropolitan Water Board for the year ended March 31, 1952, has now been published. During the course of the year the Board supplied a total of 117,836·4 million gallons, of which 2071·8 million gallons was supplied in bulk to adjacent water undertakings; a daily average of 316·3 million gallons was supplied in the Board's direct area of supply, corresponding to an average supply per head per day of 49·22 gallons. One of the events of the year was the inauguration of the William Girling reservoir, the last of the storage reservoirs which can be built in the Lee Valley; the reservoir has a capacity of 3400 million gallons and was described in THE ENGINEER of October 12, 1951. The report contains comprehensive statistics for the year of the Board's abstractions, storage and supply, covering all its various sources, and details of the various storage and service reservoirs, filter beds, engines and machinery are also given. One table in the report shows the increases in the equipment of its waterworks, since 1904.

Relieving Congestion in Overcrowded Cities

THE Minister of Housing and Local Government, Mr. Harold Macmillan, has sent to local authorities in England and Wales a memorandum on the Town Development Act, 1952, which became law during the last session of Parliament. The principal object of the Act is to relieve congestion in overcrowded cities by furthering the expansion of smaller towns suitably placed to take people from those cities. Where a city cannot find enough land in or near its own boundaries to solve its housing problems, the Act facilitates the acquisition and development of sites further afield. The present memorandum is intended to help local authorities to decide what use they can make of the Act and to suggest the kind of points they should keep in mind in doing so. The Minister hopes that authorities will be able to reach agreement by negotiations between themselves, though Ministry officials will help in informal discussions to settle any points of difficulty. The Board of Trade will co-operate with the Minister in advising the local authorities about industry for expanding towns. New industries will be necessary in most instances to provide people with work near their homes, and it is expected that such industries will come mainly from the congested areas. Under the Act, the big city which is exporting some of its population can contribute to the costs of the smaller town which is to receive them. The Exchequer can contribute in certain circumstances, for instance, towards water supply and sewerage works.

Trans-Canadian and British Railway Experiences

By EDWARD H. LIVESAY

No. V—" THE CAPITALS LIMITED "

(*Continued from page 750, December 5th*)

The author has made a number of recent journeys on Canadian and British Railways and his reminiscences of these trips are set out in this series of articles. They began with a comparison of the two transcontinental railways—Canadian National and Canadian Pacific—giving an account of a journey from Victoria to Vancouver via Nanaimo, C.P.R., and another from Vancouver to Montreal on the C.N.R. Here he extends the comparison to " The Capitals Limited," British Railways.

"THE CAPITALS LTD." is one of Britain's best post-war trains ; it is fast and well equipped, and though other trains running between London and Edinburgh almost equal it in these respects, it is unique in covering the 392 miles between the two cities without intermediate stops. By so doing it usurps the place originally taken by the " Flying Scotsman," which inaugurated this through running in 1928 and maintained it until the war, when it lapsed, in company with other adornments of a competitive railway age, and now seems to have permanently lost the distinction. In 1949 non-stop running was reintroduced with " The Capitals Ltd.," but the timing was 8 h, as against 7 h before the war. The following year this was accelerated to 7 h 40 min and in 1951 was again cut, this time to 7 h 15 min, the southbound run taking 9 min longer. Fig 21 shows " The Capitals Ltd." leaving King's Cross on its inaugural run, in May, 1949, the engine being No. 60010, " Dominion of Canada." Comparing this engine with " Commonwealth of Australia," Fig. 2, the removal of some of the streamlining will be noticed ; the object of this is, of course, to make access to the motion easier.

A fair comparison can be made between " The Capitals Ltd." and what may be regarded as its Canadian opposite number, " The Inter-City Ltd.," as both trains serve large centres and are day services ; the latter was described in last week's article. The Canadian train also runs in both directions between Toronto and Montreal, but west-bound, it is still known as " The International Ltd.," its ultimate destination then being Chicago. It was with this comparison in mind that I decided to travel on the engines of these two trains ; a subsidiary reason for making " The Capitals Ltd." the first long-distance train to investigate in post-war Britain was the fact that it was on the non-stop " Flying Scotsman " I began the locomotive experiences that inaugurated the 1939 series. By so doing I could better estimate what changes, for better or worse, had taken place during the intervening decade in equipment, power or performance, over a familiar route. It would be killing three birds with one stone—four, if at the risk of overloading the comparison " The International Ltd." is placed alongside the others. I had ridden the engine of this outstanding train ten years before (THE ENGINEER, December 5, 1941), and so could trace the effect of the war and its aftermath on these two well-known trans-Atlantic trains. The table on page 784 sets out briefly how they all compare.

A few words may be given to the " A4 " class " Pacifics," used on " The Capitals Ltd." and their forerunners, from which they developed ; only a few, as the chief dimensions are to be found in the concluding table, and nothing much can be said about them that has not already been discussed to the point of fatigue. These express engines were the culmination of the late Sir Nigel Gresley's " Pacific " designs, which began with the " A1 " class in 1922, developed into the " A3s " of 1928. From them evolved the " A4s " of 1935, refined and streamlined for the highest speeds: 20in by 26in cylinders were first used, a moderate steam pressure, 180 lb, and short-travel valves. Then came the " A3 " class, which benefited from the example set by the Churchward " Castles," the fine performance of these being largely the result of higher pressure coupled with long lap and travel valves. Exchange running made this quite clear ; the " A3s " were given these modifications and the " A1s " were converted to correspond, and with them did proportionately better work. Finally, when in 1935 a super-fast train, the " Silver Jubilee," was to go into service, the "A4" class was designed to handle it and other fast trains, which it did with complete success. I will not gild the lily by indulging in any panegyrics over the " A4s " ; they have spoken for themselves for a good many years. On the contrary, I am going to indulge in a little criticism of one or two details I have never been very fond of, saying so, diffidently, at the time my first " Experiences " with these engines were published in THE ENGINEER over a decade ago. For obvious reasons I can do so more openly now, as subsequent " Pacifics " coming from Doncaster have shown clearly that wiser heads than mine found fault with the same points. The conjugated gear for working the inside valve is one of them : it never seemed to me necessary, there being plenty of room for a separate set of gear between the frames ; it was potentially troublesome, upsetting valve-events when wear took place more than an individual set would do. It can be little, if at all, simpler than separate gear, and the fact that subsequent " Pacifics " have not been fitted with it would seem to show that its disadvantages have been recognised in quarters where the pros and cons are on file.*

* Admitted, the leading driving-axle rather gets in the way of a third set—which makes the first part of the following paragraph apropos.—E.H.L.

Three connecting-rods driving on one axle can also be criticised, and that arrangement, too, has not been perpetuated. Why not divide the drive when another axle is available ? Again, I suggested in the original article that the " Cartazzi " trailing truck, too, when in good condition, was satisfactory enough, but when wear developed the action was worse than when a Bissell truck got into a similar state. This was confirmed by Mr. Bowen, ex-Superintendent of Motive Power, C.P.R., who fitted the " Cartazzi " type extensively. He explained it was only used on engines not intended to travel at high speed, and it was employed because it was cheaper and lighter than the Bissell, not because it was as good. However, the " A4s " are very fine engines, for which I have every respect.

" The Capitals Ltd." leaves King's Cross at 9.30 a.m. ; No. 60024 " Kingfisher " backed down on to the train with enginemen Howard and Ward in the cab ; they were joined by Inspector Hart, who had been considerately told off to supply me with any technical information and assistance that might prove necessary. On these non-stop trains a compartment in the first coach is reserved for the enginemen off duty, in this case the Scottish pair, Messrs. Gimel and McConnell, of Haymarket, who would be taking over from the King's Cross crew at Tollerton, the halfway mark, a little north of York. The tender is vestibuled to the train to facilitate transit between engine and coaches at any time, via a narrow corridor along the right side—a great convenience.

Fig. 21—" The Capitals Ltd."

" Kingfisher " moved out of the station promptly at 9.30 a.m., the twelve-coach, 450-ton (gross) train and dry rails giving no reason for slipping with a 40 per cent cut-off and half regulator. I was again pleased with the hanging " both sides " handle—which has been adopted on the new " Standard Pacifics," too—so easily worked and controlled, which should make slipping even less likely. A multi-valve regulator has similar value. The operation of the reverse by a horizontal handle and the position of the scale, flat up against the back plate, straight in front of the driver's eye, is another admirable arrangement, by which an observer benefits too—especially if he is of the " cut-off-and-regulator " school.

Before visibility and ceiling alike became nil in the Gas Works tunnel, Hart thoughtfully warned me that the flap-plate covering the gap between engine and tender could, if ignored, turn vicious and nip the foot of the unwary between its end and the side of the tender when a sharp curve was being negotiated. I promised to treat it with the respect it demanded—so long as my memory lasted.†

The profile of the old G.N.R. main line is so well known that there is no need for me to do more than remind the reader at this stage that a climb begins immediately the platform at King's Cross is cleared, with a mile of 1 in 107 through the Gas Works and Copenhagen tunnels, followed by 3 miles of level, then slightly rising and then descending inclination to a point beyond Hornsey. This introduction to the major task just served to get things going, lubricant flowing, the cylinders nicely warm, and so on, raising the speed to 45 m.p.h. before "Kingfisher" began the 8 miles bank of 1 in 200 ending at Potters Bar. At Oakleigh Park, approximately halfway up, the Flaman recorder under the fireman's seat would have registered about 35, if there had been one, but there wasn't. The reader is therefore warned that all speed figures in this article are only approximate, but are quite accurate enough for all practical purposes; no doubt they will be anathema to "timing and measuring" pedants. The absence of this fascinating device from the cab equipment of all the engines I have ridden in England recently is one of the regrettable post-war changes noticed; the need for economy by the exclusion of all non-essentials is presumably the explanation,

At Hadley Wood, nearing the top of the bank, an adverse signal cut the speed, threatening to bring the "Capitals" to a stand; it went off just in time and the peak was passed at 30 m.p.h. at 9.51; "Commonwealth of Australia's" figure had been 60, unchecked. Thence there was a speed restriction of 60 to Hatfield; then of 70 to Welwyn, where p.w. work brought the train right down to 20, apart from limitation over the viaduct; to and over the Langley troughs it was 60 and here water was picked up. A long, 8 mile, descent begins at Stevenage, followed by a generally falling gradient to Tempsford, down which "Kingfisher" reached 70/75, as against "Commonwealth's" 90 in 1938. On that occasion I recorded the riding as being "very good—practically as steady as at more moderate speeds." No. 60024's was given as "fair," a not too enthusiastic entry that had to be marked down subsequently in the light of further experience. Passing Hitchin, Hart reported the "Capitals" "dead on time." I simultaneously jotted down: "audible box-pound on right side—wedges?" Running nicely at speed along the straights that distinguish this stretch, the details listed were: "half regulator, 15 per cent cut-off, pressure 230 lb, steam chest 150—blowing off takes place just below 250, steaming good." There was considerable rolling and oscillation but very little opposing motion between engine and tender, indicative of good coupling-gear and control, of which I believe buffers form part.

Ward, unlike Floyd of '38, was evidently an exponent of the "little and often, mostly at the back and rear corners" firing method, and kept the door well open. He gave Yorkshire coal a good reputation but said its tarriness made care necessary, as it was apt to cake. He was kept fairly busy, the little-and-often system making long "spells," such as Floyd had indulged in between times, impossible. Nevertheless, he did not have to over-exert himself, so I was correspondingly at ease—mostly in his seat, which he persistently refused to deprive me of. I marked him down as a capable, good-natured individual; as regards Inspector Hart, his character will be given later; my only complaint of him was and still is that he was too self-sacrificing and conscientious! From Howard's side of the cab I gathered that the popular pre-war "full regulator and minimum cut-off" fashion had gone into the discard since I last rode an "A4"; certainly there were no signs of it aboard "Kingfisher." "For this relief, much thanks"; it gave me another excuse for not boring either the reader or myself with meticulous notes of something that generally does not amount to much, and frequently is introduced into accounts of locomotive work to conceal the fact there isn't much else to say. Incidentally, along here I noticed a few of the old "somersault" signals, not yet replaced by the more modern upper-quadrant pattern.

Huntingdon, passed at 60, brought from Hart the information that the last 27 miles had been covered in 22½ min, 72 m.p.h., which sounded quite impressive until, on consulting the gradient book, it was evident that the profile had been mostly level and downhill; then it merely confirmed the impression that was gathering strength the farther north we went, that the run was not likely to be anything but a "routine" performance, during which neither engine nor crew would be called upon to do anything much out of the ordinary. It looked as if I might as well resign myself to mediocrity; that is, to something meritorious but "nothing to write home about." The schedule was generous, the load moderate, the route not very demanding, save here and there, and the engine capable of doing far more than was being asked of it. Three miles of 1 in 100 begin at Huntingdon, on which the speed fell to 40; over the top and down similar inclination through Abbott's Ripton it was allowed to touch 75; the schedule called for nothing higher, even if the permanent way would allow of it; we were 1 min ahead at this point. From Connington, at the foot of the descent, it is almost level for 20 miles through Peterborough (10·52½), where "Kingfisher" blew-off for the first time, a shut regulator and cautious approach to an adverse signal, coupled with a permanent restriction through the station being responsible; this signal, too, went off barely in time to prevent a halt, and the spoiling of the "Capitals" non-stop run. Another 1500 gallons of water were picked up at Werrington; I was told that 4000 can be lifted if necessary. Here I noted that the tender rode very much better than the engine—*very* is heavily underlined. Perhaps this is only to be expected—it generally does—but the emphasis is suggestive. All along this section and up the 20 mile pull to Stoke Box, on which the cut-off was 15 to 20 per cent associated with almost constant two-thirds regulator or less—I must give the "v.t. and reg." people something to chew on—the performance was reported in my log as "jog-trot and unambitious"; so much so that when Howard almost insisted on my taking his seat for a while I had no qualms about doing so, as it didn't seem to matter much who was in it, so little was happening. Or perhaps I was enjoying one of the privileges of—let us say, *advancing* age, the other people in the cab having already fallen into the habit of waving me back to Ward's seat whenever I offered it to anyone, or merely wanted to stand up and stretch my legs.

From Stoke Box to Grantham—12.27 and 2 min late—and on through Newark to Crow Park, it is mostly falling or level track for 27 miles, with Muskham Troughs *en route*, but the speed never exceeded 75. Scrooby and another pick-up, though these troughs are only 24 miles past Muskham; the tank was now filled to overflowing, as it was 74 miles to the next troughs, Whiske Moor. The weather was still fine, but getting cool and overcast, and the wind, a trifle on the beam, carried the exhaust well clear of the cab windows, helped by the horizontal wedge front and streamlining. Doncaster, passed at 12.17½, 1½ min early, marked the beginning of 85 miles of such easy going that I anticipated little worth noting for an hour or more, so both engine and I could relax—admitted, neither had been seriously stressed so far. A signal slowing at Shaftholme; momentary interest in a war aerodrome at Templehirst, with hundreds of tanks under tarpaulins on the other side of the line, stored against the possibility of another "bigger and better" war; more signal delays at Balne and Heck, and a permanent restriction nearing the swing-bridge at Selby; again at Riccall and Escrick, probably with a similar bearing on the swing-bridge at Naburn. Hypnotised by the placidity of this stretch, I watched the countryside stream by, listening to the rhythmic thudding of the obtrusive axlebox; a slight drizzle set in. York then loomed up ahead and after the ritual slowing, the "Capitals" ran carefully through the great curved station, surely the finest between London and Edinburgh; time, 12.41, 3 min late.

York opens the door to a fine section of 13 miles, level and mostly straight, and while negotiating it, at Tollerton, the change of watch, a requisite of these non-stop runs, takes place. The Scots crew, Messrs. Gimel and McConnell, came into the cab via the corridor, freeing the four previous occupants from their duties *pro tem*, enabling them all to go to the dining-car for dinner, which they did—via the buffet. I noticed that the navigation of this narrow steel passage was not obstructed by fire-irons (as it had been in '38) much to the relief of my shins, and we took our seats after a wash-and-brush-up; very perfunctory in my case, less so in Howard's, and *very* much less so in Ward's, with the result that for the rest of the journey—but that is another story.

Nothing appears in my note-book for the next 90 miles; dinner, the buffet and the reserved compartment, with its comfort and cushions, evidently wrought havoc with the log. But probably little of importance was missed, as visual and sensory observations gave no indication of much change in our rate of progress, and the gradient book showed nothing worth bothering about until beyond Darlington, which was pinpointed through the window, and the fact noted that we were 9 min late. Passing Durham, where there is a drastic speed restriction, 10 min had been lost, but not until the train was clattering over the complicated junctions and crossing at Newcastle did I come to a realisation of the fleeting miles and minutes, and admit it was time I got back to the cab and my duty. This is a much "restricted" area; past King Edward Bridge Junction; over the bridge, through the station and on to Manors East; all this stretch had called for very careful running, switching from the main to the slow line, and further con-

† But Hart himself forgot! See the concluding paragraph.

servative travel to Heaton, due to permanent way work. Finally, at Plessy, virtue triumphed and I returned to the engine, finding everything going on just as before, quite placidly, though it did seem we were travelling a little faster. Yet at Morpeth, where there is another restriction, we were still 10 min late, but now, down through Longhirst and Acklington, a certain liveliness became apparent, the speed rising to 80. However, the spurt was short-lived, a p.w. caution at the latter place bringing the train down to 10 m.p.h., and giving me an opportunity to note the board passed shortly afterwards—" London, 300 miles " ; time, 3.09, 339 min since leaving King's Cross, average 53. Nothing very strenuous about that ; they did far better in the race to Aberdeen over half-a-century ago !

From Alnmouth to Little Mill, 4 miles, there is a climb at 1 in 170 ; the cut-off became 20 per cent with regulator two-thirds, but I had long since ceased to pay much attention to them, as it was evident that neither Howard nor Gimel were playing symphonies on either, so the exact ratio of one to the other, or to anything else, revealed nothing of any importance to me, nor would it to the reader, and it was a relief to feel that I could deliberately disregard the pair of them. I know it is more or less a footplate convention to record punctiliously what happens to these two controls, but on a casual run such as this, when no effort is being made to achieve the spectacular, it is love's labour lost—and I never was conventional, anyway.

Following Little Mill, descending or level track extends past Lucker troughs to Goswick. There a serious wreck occurred a few years ago, due to a driver ignoring a speed restriction imposed during p.w. repairs, the engine and part of the train, travelling south at high speed, leaving the metals, the presence of an unauthorised person in the cab possibly contributing to the accident. Near Goswick, another kind of wreck came into sight, a stranded freighter, beached, lying wearily on her side, pounded by the rollers, at the mercy of every easterly gale. I was told her distress signals had been seen from a nearby signalbox, and prompt steps had been taken leading to the rescue of her crew.

On the long, descending section from Little Mill the impression of a " certain liveliness " in our running gained ground once more ; 75/80 was hit and held for several miles, but as " The Capitals Ltd." was still behind time this improvement would have to be maintained if Gimel was really going to make a sustained effort to get back on to schedule. The stiffish climb from Goswick through Berwick and over the Border to Grant's House was just ahead, 17 miles, mostly 1 in 190/200, and Edinburgh was only 75 miles away. Undoubtedly we were travelling faster than usual, and more consistently ; invariably I had to stand up to write, a sure sign of turbulence underfoot, confirmation of which has since been provided by difficulty in reading my own notes. But not Inspector Hart's ; he has considerately rewritten his log for my especial benefit ; it is clear and easy to read. I should be sorry for him if we had exchanged records ! I may explain that most of the times at passing points are taken from his journal, as not only have I greater faith in their accuracy than in my own, but had felt all along there was no need to bother looking at my watch so long as he kept consulting his. After all, why keep a dog and do the barking yourself ?

Berwick to Grant's House is fairly heavy going ; 17 miles, 12 of them 1 in 190/200, with frequent curvature, yet the cut-off was only 18/20 per cent, and the regulator was never more than two-thirds open—I bring this in to satisfy the v.t. enthusiasts ; it gives an air of intimacy to the story. The Border, with its " England-Scotland " sign, was crossed at speed, but neither Hart nor I noted the time—each depending on the other, no doubt, and letting each other down. Grant's House, practically the summit, was passed at 4.01—by my watch ; Hart seems to have neglected this crucial point too. The 17 miles had been covered in 20 min, 51 m.p.h., quite a respectable figure, considering the severity of the climb, yet far short of what " Kingfisher " could have done at a pinch. Once over the top and clear of the succeeding tunnel, the speed rose rapidly as the train dropped down the steep 4 miles long 1 in 96 Cockburnspath bank, with the two additional miles at the foot of 1 in 210, ending at Innerwick. For a considerable distance it remained about 75, and the whole character of the running seemed to have taken a change for the better. It was pleasant to feel that " Kingfisher " was at long last really trying to get somewhere quickly, instead of contentedly ambling along behind time, ignoring the loss of the unforgiving minute, when she might have been filling it with sixty seconds' worth of distance run, indifferent to the disillusionment of the passenger in the cab, to say nothing of the impatience of the people back in the train. It is lovely country along here, with the sea in full view on the right, but I was not thinking about either ; my mind was busy with the over-riding speculation : " Shall we get to Edinburgh on time, or shall I have to record a failure to keep even this easy schedule ? " At Longniddry, 28 miles beyond Grant's House, the speed was still 75, as it had apparently been for some time, so surely success might yet crown the efforts of " Kingfisher " and her Gaelic crew on their home stretch ? And it did ; for at Prestonpans Hart shouted in my ear : " We're back on time ! "—and simultaneously it began to rain. It has since looked to me that we must have been not merely " back on time " at Prestonpans, but ahead of it, though as fortunately neither Hart nor I recorded the passing figure, I am not obliged to solve the tangled mystery that must have resulted if either or both of us had done so. Expanding this : had " The Capitals Ltd." been only " on time " at Prestonpans, I don't quite see how it managed to gain 5 min over the succeeding 9 miles to Waverley, which included a final mile of 1 in 78 up, and coming to a stand in the station ! Yet according to Mr. Hart, the " Capitals " did just that ; verily there must have been some meteoric travelling through suburban Edinburgh, and it is curious I have no recollection of it. On the contrary, there lingers in my memory a somewhat cautious approach from Piershill up that culminating mile, and a gentle coming to rest in the station 5 min early at 4.45 p.m. So the

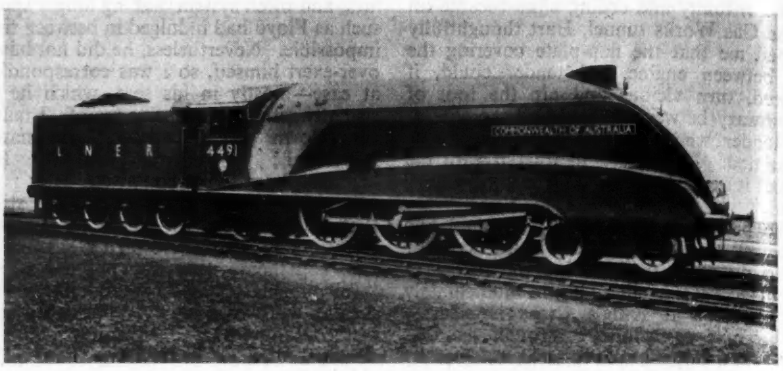


Fig. 22—" Commonwealth of Australia "

Train Comparisons

	1938	1951	1941	1951
	" Flying Scotsman "	" Capitals Ltd."	" International Ltd."	" Inter-City Ltd."
	London-Edinburgh	London-Edinburgh	Montreal*-Toronto	Toronto-Montreal*
Depart	10 a.m.	9.30 a.m.	3.15 p.m.	4 p.m.
Arrive	4.57 p.m.	4.45 p.m.	9.30 p.m.	10.10 p.m.
Distance (miles)	392	392	331	331
Running time (min)	417	435	339	313
Stops	None	None	Six (36 min)	Six (57 min)
Average speed, exclusive of stops	56·4 m.p.h.	54 m.p.h.	58·6 m.p.h.†	63·4 m.p.h.†
Maximum speed	90 m.p.h.	80 m.p.h.	80 m.p.h.	80 m.p.h.
Weight of train (approx. tons)	470	450	950	1,000 +
Number of crews	2	2	3	3
Mileage by one crew (max.)	200	200	125	125
Class of train	Day : dining-car and buffet	Day : dining-car and buffet	Day : dining-car and buffet-parlour	Day : dining-car and buffet-parlour
Locomotives	" A4 " " Pacific," 4-6-2 No. 4491 " Commonwealth of Australia "	" A4 " " Pacific," 4-6-2 No. 60024 " Kingfisher "	" Hudson," 4-6-4 No. 5704	" Mountain," 4-8-4 No. 6200
Cylinders	18½in by 26in (3)	18½in by 26in (3)	23in by 28in	25½in by 30in
Driving wheels	6ft 8in	6ft 8in	6ft 8in	6ft 1in
Heating surface	3,325 square feet	3,325 square feet	4,842 square feet	5,915 square feet
Superheater	749 square feet	749 square feet	1,465 square feet	1,835 square feet
Pressure	250 lb	250 lb	275 lb	280 lb
Grate area	41·25 square feet	41·25 square feet	73·6 square feet	84 square feet
Tractive effort	35,455 lb	35,455 lb	43,300 lb	45,000 lb
Tractive effort	—	—	10,100 (booster)	12,000 (booster)
Factor of adhesion	4·18	4·18	4·36	4·33
Weight (engine)	103 tons	103 tons	159 tons	180 tons
Weight (tender)	64 tons	64 tons	130 tons	124 tons
Coal	8 tons	8 tons	18 tons	18 tons
Water	5,000 gals. (pick-up)	5,000 gals. (pick-up)	14,000 gals.	11,600 gals.
Firing	Hand	Hand	Mechanical	Mechanical
Valve gear	Walschaerts	Walschaerts	Baker	Walschaerts

* Times and distances taken from and to Montreal West Station ; trains run to Windsor Station, 4·7 miles, C.P.R., the actual terminal, calling also at Westmount. Engines used are C.N.R. rolling-stock mixed, C.N.R. main line utilised between Dorval and Toronto.

† No allowance for slowing to, and regaining speed after, stops.

record reads : King's Cross dep. 9.30 a.m. ; a trifle ahead of time at Doncaster, 156 miles ; then consistently behind schedule until 10 min in the red at Durham, 254 miles, remaining there most of the way to Prestonpans, where we got back on time again—and then a gain of 5 min in the last 9 miles ! No, there's something appropriately fishy about " Kingfisher's " grand finale. But, after all, what does it matter ? " The play, the play's the thing, wherein we'll catch the conscience of the King ! "—" fisher " understood. The run, the run's the thing, and what happened aboard the engine *en route* ; that is what I have tried to portray. Whether we arrived at our destination a few minutes ahead of time or behind it is of little importance, though there would have been little excuse for the latter. " Kingfisher " and her two crews had between them done their jobs successfully ; 392 miles in 435 min non-stop, average speed 54 m.p.h. A simple, straightforward performance, with nothing much needing elucidation except those mysterious minutes picked out of nothing north of Prestonpans. That Final Problem I cheerfully leave some to Sherlock Holmes with a stop-watch and steel tape.

This vignette of " The Capitals Ltd." and abstract of the work done by an " A4 " engine hauling it is admittedly neither analytical nor theoretical, and is not intended to be. Why thresh old straw ? It is merely a plain statement of what an " A4 " has to do, and did, when handling one of Britain's premier post-war trains ; it is a record of performance only. In the absence of a dynamometer car any attempt to assess power output, coal and water consumption, and so on, under the conditions of such a modest run as this would be purely empirical and of no value, as at no point was the engine extended or any very heavy work involved. A brief study of the time-table and gradient book—of course, amplified by this account !—bearing in mind the load hauled, shows clearly enough what the engine was called upon to do—which was nothing very much and considerably below what " Kingfisher " was capable of. Far more ambitious work was done many years ago, particularly just before the war, in ordinary, everyday running. It may be asked why more is not done now ? Goodness may know and the Railway Executive certainly does—I don't.† So far as the engines are concerned I have no doubt an hour could well be cut from the schedule, and time still kept. I confess that I am not quite able to see the advantage of the non-stop running, which calls for a corridor tender and two crews on duty simultaneously, when a stop of one minute, just outside York Station, to change crews, would neither inconvenience the passengers nor affect the overall time. Perhaps the fact that the corridor tenders, first put into use in a less austere age, are still *in esse* has induced the railways to employ them again for the same purpose they were originally designed to satisfy. However, there they are and again in use ; at any rate the corridor is a great convenience for crews and observers ; there is that to be said for it—now that the fire-irons are kept out of it. For example, what use would the buffet have been to me in the absence of a corridor-tender ? None—merely an exasperation instead of a joy.

I will conclude with a quotation from Inspector Hart's log, which I was gratified to find confirmed my own impressions jotted down in the cab at the time ; there was no collaboration between us : " Engine riding rough, condition indicating heavy mileage ; steaming satisfactory." It was rough, but not nearly so much as experienced on No. 6200 with " The Inter-City Ltd." ; I did want to sit on something soft after that !

Some days later, meeting Inspector Hart in London, I learned to my disquiet that when " Kingfisher " was pulling away from the platform at King's Cross, taking the sharp curve out of the station into Gasworks Tunnel, his foot had been caught by the end of the steel flap covering the gap between engine and tender, cutting right through the leather of the shoe and seriously crushing and bruising his foot against the side of the tender. Though he must have been in real pain all through the day, neither by word nor deed did he confess it, standing most of the long journey on that vibrating, unstable footplate, always considerate of my comfort, disregarding his own, courteous and helpful. Inquiring why he had said nothing of the mishap either to the crew or myself, he replied : " Because I thought it might worry you, and spoil your trip." He was right in so thinking—it certainly would have ; had I known of it, I should have insisted on his going back into the train and if, Casabianca-like, he had refused to do so, pleading duty, I should have gone there myself, so making it unnecessary for him to carry on in the cab ; the run would have been given up and done some other day. I am glad to record this incident because such actions revive and renew respect for one's fellow men when it shows signs of weakening—as it sometimes has a tendency to do, I find, in a Welfare State.

(To be continued)

† Subsequent reflection, confirmed on inquiry, has led me to the conclusion that the condition of the track may be the deciding factor. It is not yet back to pre-war solidity, due to shortage of material and labour, and a large number of restrictions still exist that make high average speed unattainable at present. I have mentioned a good many of these hindrances in this article, and probably there were others which the crew paid attention to, but I didn't, not knowing of them. It is strange, however, to see this seemingly perfect British track peeling away underneath and to be told it is not considered safe for faster travel. Permanent way people in England should see the sort of track that in Canada is looked upon as good enough for 300-ton engines to travel over at high speed ; they would probably finish their journey by bus. Evidently very different standards are set up in the two countries and I am not saying I admire the Canadian. But I sometimes wonder if the British standard is not set needlessly high.—E. H. L

The Iron and Steel Institute

AUTUMN GENERAL MEETING

No. II—(*Continued from page 767, December 5th*)

At the afternoon session of the Iron and Steel Institute's autumn meeting on Wednesday, November 26th, the chair was taken by Mr. James Mitchell, the president-elect. There was a discussion of " The Thermodynamics of Steelmaking," which was based on a paper on " Development of Active Mixer Practice at Appleby-Frodingham," by A. Jackson, introduced by the author, and on the following group of papers, for which Dr. F. D. Richardson acted as rapporteur :—

" Thermodynamic Properties of Silicon Monoxide," by N. C. Tombs and A. J. E. Welch ; " Phosphorus-Oxygen Equilibrium in Liquid Iron," by J. B. Bookey, F. D. Richardson and A. J. E. Welch ; " The Free Energies of Formation of Tricalcium and Tetracalcium Phosphates," by J. B. Bookey ; " The Free Energy of Formation of Magnesium Phosphate," by J. B. Bookey ; " Effect of Sodium Oxide Additions to Steelmaking Slags : II—Dephosphorisation of Steel by Soda Slags," by W. R. Maddocks ; " Phase Equilibrium Investigation of the Na_2O–P_2O_5–SiO_2 Ternary System," by E. T. Turkdogan and W. R. Maddocks ; " Thermodynamics of Substances of Interest in Iron and Steel Making : III—Sulphides," by F. D. Richardson and J. H. E. Jeffes ; " A Stoichiometric Combustion Method for the Determination of Sulphur in Slags," by C. J. B. Fincham and F. D. Richardson, and " The Thermodynamic Calculation of Slag Equilibria," by H. Flood and K. Grjotheim.

DEVELOPMENT OF ACTIVE MIXER PRACTICE AT APPLEBY-FRODINGHAM

By A. Jackson, A.Met., F.I.M.

Synopsis

This paper describes experiments on the treatment of iron between the blast-furnaces and the mixer, and the development of mixer practice, at the Appleby-Frodingham Steel Company.

The first part discusses open-top and semi-closed ladles for metal transfer ; trials of insulated ladles ; loss of sulphur by flotation from the iron during transit, and the effect thereon of additions of manganese-bearing materials to the ladle at the blast-furnaces ; treatment of molten iron by ladle reaction with iron oxide, limestone and fluorspar ; the removal of silicon, manganese and carbon by oxygen lancing, and the use of soda ash for desulphurisation.

The second part considers mixer construction, design and refractories ; fuels and fuel consumption ; the effect of iron quality on mixer capacity ; the method of feeding, using local ironstone or limestone and scale ; the mixer process developed in a steel furnace ; the effect of rate of feeding on sulphur removal in the mixer, and the effects of the high and low-silicon iron produced on steel furnace production rates ; the loss of sulphur in transit and mixer operation, with the effects of mixer slag volumes ; the general results obtained, and a method of estimating operational efficiency ; the effect of direct and mixer iron on steel furnace production, and the oxygen lancing of mixers.

Discussion

Mr. W. A. Cameron (Colvilles, Ltd.) : I propose to confine my remarks to Mr. Jackson's paper, which, from the details given of modern mixer practice and the record of experimental work on the treatment of molten metal between the blast-furnace and the mixer, is of immediate value to the industry. The development of mixer practice since 1937 is well illustrated in Tables III and IV in the paper, and the advantages of modern design and methods are clearly shown. It is interesting to note that the recent results given indicate that the work done in the mixer is equivalent to a reduction in the metallurgical load in the open-hearth furnace of about 40 per cent. This is based on potential slag volume when using mixer metal as compared with direct blast-furnace iron, assuming that no primary slag is removed. A reduction of this order should mean increased output from steelmaking furnaces, which will vary with the iron burden used, being probably negligible at 30 per cent or under, but reaching the value of 25 per cent given by Mr. Jackson on a 75 per cent hot metal burden. Table VI, giving the effect of mixer slag volume on sulphur loss, gives results which are somewhat unexpected, in that it shows a loss of sulphur from the slag when the slag volume is low, and a gain when the volume is high. It seems reasonable to suggest that, since the higher slag volume practice in recent years is made possible by a higher temperature of operation, and that this was achieved by a change in firing practice, the nature of the gas used may provide the explanation. Blast-furnace gas, used during the years when oxide and limestone feeding was low, is, of course, almost sulphur-free, and a

sulphur loss from the slag could be expected ; but this condition may have changed with the introduction of a proportion of coke-oven gas having an appreciable sulphur content which may have led to sulphur transfer from gas to mixer slag.

Mr. R. W. Evans (Steel Company of Wales, Ltd.) : I am not a thermodynamic chemist or physicist, and there is a great deal in some of these papers which I do not understand, but we must see whether there is any way of translating the ideas contained in them into practice at the iron and steel plants. In spite of progress in elucidating the physics and chemistry of processes at high temperature, steelmaking is still largely an art and not a science. Indeed, on this account a steelmaking operator, on every charge that he taps on an open-hearth furnace, has, subconsciously perhaps, to balance the probability of a number of contingencies happening, and to the best of his ability steer the correct course through these often conflicting tendencies. He is dealing with four phases : the gas, the slag and metal, which are molten, and the hearth, which is solid—at least, on most occasions ! Equilibrium rarely obtains in these systems, and each of the phases may be changing rapidly in composition even while he is deciding his action when he comes near to tapping the furnace, and, to make it more difficult, the four phases are all at temperatures somewhere about 1550 deg. Cent.

The perfection of flow and temperature-measuring techniques has enabled operators to exercise more control, but even now, some eighty years after the first heats were made in Bessemer converters and in open-hearth furnaces, we are still far from being able to make our results scientifically reproducible. Surely, therefore, the steelmaker, above all other manufacturers, has a need of exact qualitative and quantitative knowledge of the high-temperature reactions which govern the efficiency and economy of his processes. One of the difficulties, however, is to transfer fundamental conceptions and results to practical applications in the steelmaking processes. Indeed, a very precise knowledge of the chemical composition of the phases and of their temperature will be a *sine qua non* if advantage is to be taken of results such as are indicated in these investigations into thermodynamic principles. It must be borne in mind that a great deal of work is now being done all over the steelmaking world on these problems. Thus it is necessary that we should have means of making quick and accurate measurements and analyses if we are going to avoid a situation developing where a large amount of useful knowledge is available, but we are unable to put it to practical use. The average open-hearth operator has not the time, nor in many cases will he have the technical equipment (by which I mean his own technical equipment), to deal with conceptions such as are embodied in these papers, and therefore we may consider that, after these investigations, another step must be taken, also at a fairly high theoretical level, by which these conceptions can be translated into ideas which will definitely help the open-hearth operator.

Mr. D. A. Oliver (B.S.A. Group Research Centre) : I feel that sooner or later the practical steelmaker has to become accustomed to this thermodynamic notation. If I may indulge in reminiscence for a moment, we came to the conclusion a few years ago that we ought to have, and by the combined efforts of several people we obtained, an English translation of Schenck, which had the great advantage that when one made a substitution for a formula which was in error one was enabled to correlate the theory with the practice to quite a considerable extent. Following that, naturally the new researches show where Schenck was wrong, and what we want now is a new Schenck. I regard these papers which are being written now as fragmentary parts of important chapters in this new story, and those who are not immersed in the subject are set a very ticklish problem to know to what extent these formulæ can be applied in practice. Even on those parts of the subject to which I thought that I had given some considerable attention, I am frankly still bewildered about the limitations in application. Another confusing matter is the accuracy of these thermodynamic data. I do not mean that the papers which we are now discussing are not accurate, but I am looking at the subject broadly, and I think that the authors of these papers and Dr. Richardson will agree that some data are so terribly bad that they should be rejected completely, while other data are extremely good. There is also the question of notation. It is a tragedy that thermodynamics has managed, somehow or other, to give birth to about three kinds of algebra, and the moment you come to try to apply them you find that the authors whose work you are considering have used yet another symbol, which is not one with which you have familiarised yourself. All these difficulties are worth reviewing, because they are holding up our advance in application. I should not like what I have said to be interpreted as grumbling. It is simply a general review of the difficulties, and I will conclude this part of my remarks by saying that I hope that the publication of a British book which will contain all the answers is not far off.

Mr. P. Walker (Cargo Fleet Iron Company, Ltd.) : To some extent Mr. Jackson's practice and my own are very similar ; the main difference is that Mr. Jackson's steelmaking units are somewhat larger. In looking through this paper, therefore, I expected to find something which might apply to our practice. The two items on which I concentrated are (i) the effect of manganese content of the blast-furnace iron delivered to the mixer, and (ii) the conditions which arise in an open-hearth shop when an active mixer is off for repairs. As a basis for some remarks on those two subjects I should like to refer to a table headed " Effect of Increased Manganese in Pig Iron on Sulphur in Steel." There are three periods shown. In the first two the active mixer is working, and in the third it is off for repairs. If we take the second period first, we had a 0·66 per cent manganese content in the iron. After working for some time with that manganese content we felt, and we believed that we had had evidence to show, that that manganese content was too low.

In passing, it may be of interest to show that there has been a tendency for manganese in the iron to come down. In the 1938 symposium, out of eight manganese contents mentioned in the various papers, seven ran between 1·2 and 1·4 per cent for basic open-hearth iron. At any rate, we came to the conclusion that the manganese should be put up, having in mind particularly its effect on the refining time for sulphur and on the sulphur in the finished steel, and so we put the manganese up, aiming at 1 to 1·2 per cent. In the first period, in which the manganese was put up to 1·06 per cent, we had 0·93 per cent of silicon and an average of 0·093 per cent sulphur. The table shows what we got in refining time and the analysis of the iron from the mixer. We got 0·055 per cent sulphur against 0·093 per cent. We obtained 0·8 per cent manganese against 1·06 per cent. With the iron containing 0·66 per cent manganese we had 1·11 per cent silicon going to 0·54 per cent, and the other reductions which are shown.

The last line shows the sulphur in the steel at slagging. In our hot metal tilters we take slag off and put new lime on to form what we term the finishing or refining slag. For the 1·06 per cent manganese iron the number of charges is 194. We have taken a figure of 0·065 per cent sulphur at slagging, because it is our experience that if we get that sulphur or anything under it we have nothing to worry about so far as sulphur is concerned. With the higher manganese iron, 78·6 per cent of our charges slagged at a sulphur of 0·065 per cent and under. Going on to the finished steel, with 554 casts, and taking a sulphur figure of 0·045 per cent and under, we achieved this with 381 casts, or 68·8 per cent. With the 0·66 per cent manganese iron we had 164 charges, and 34·7 of them had 0·065 per cent sulphur and under, and in the finished steel we had 30·3 per cent fulfilling our requirement, compared with 68·8 per cent. The importance of the figure of 0·045 per cent and under is that we get quite a number at 0·035 per cent and down to as low as 0·03 per cent, and those, without a doubt, have a very beneficial effect on the surface of our products. The third period is the one which gives us trouble, because in this period the active mixer was off and we had to rely on the inactive mixer, so that what we were really dealing with was almost double the silicon as compared with the other practice when the active mixer was used. We had 186 charges, and 9·1 per cent slagged at the figure of 0·065 per cent sulphur and under, as against 34·7 and 76·8 per cent, while for the sulphur in the steel we had 7·13 per cent at 0·045 per cent sulphur and under as against 30·3 and 68·8 per cent. I think you will agree, when we come to this practice, that it behoves us to try in future to do something about it. On this occasion the mixer, through unforeseen circumstances, was off for rather longer than had been expected. Nevertheless, it is a part of our practice about which something should be done to do away with the tremendous increase in refining times coupled with a steel which is far too high in sulphur, with its consequent detrimental effects in rolling.

Mr. V. Giedroyc (Imperial College of Science and Technology) : I should like to make two points on Mr. Jackson's paper. It is clear that it cannot be expected that an active mixer can play two roles, to remove silicon and to desulphurise the iron. This limitation in respect of sulphur, which is mainly due to oxidising conditions prevailing in the mixer, cannot be changed without having a profound negative effect on the removal of silicon. It is true that flotation of manganese sulphide can lower sulphur in the metal, but this method is expensive and wasteful. It becomes increasingly important, therefore, to remove sulphur before the metal is transferred into the mixer. Many steel plants have already been doing this by using the soda-ash process with varying degrees of success. An alternative method of desulphurisation using solid lime would seem to be more satisfactory, but has not yet been sufficiently tried on a works scale. Not only can the problem of sulphur removal be solved by the use of solid lime, but also the other problem, that of blast-furnace slag finding its way into the mixer. Mr. Jackson has emphasised the deleterious effect of this slag. If a " teapot " ladle, filled with lime-coated coke or some similar material, is placed between the transfer ladle and the blast-furnace runner, not only do we achieve a considerable degree of

desulphurisation, but also all traces of blast-furnace slag will be removed. It is not even necessary to have such an elaborate method as this. Even an ordinary ladle can be used, and by filtering iron through the material we effect a considerable degree of desulphurisation.

Mr. J. Pearson (British Iron and Steel Research Association): My position in regard to the papers which Dr. Richardson has presented is that of a non-active participant, the sort of person who, at the end of the paper, is thanked for his valuable advice. I stand between the two camps, that of the practical man, on the one hand, and of the man who wrote the paper on the other, with a bias towards the latter. I should like to comment on what Mr. Oliver has said about the chemical analysis of acid open-hearth slag and the views of Schenck. Schenck, as Mr. Oliver pointed out, regarded some of his 15 per cent of FeO as combined, and some as free, and in the example given by Mr. Oliver 10 per cent was regarded as combined, and 5 per cent as free, which by application of the partition coefficient would enable us to calculate the oxygen in the metal. So far as the SiO and SiO_2 in this system are concerned, we can say at once that it does not worry us at all. If we have FeO in the slag we must have oxidising conditions such that SiO cannot exist. On this question of the amount which is bound and the amount which is free, we research workers have got into the nasty habit of calling this the activity, so that in this case we should refer to a 33 per cent activity or a 0·33 per cent activity. What Mr. Oliver wants to know is how from this sort of thing to tell what that 5 per cent is. That has been studied, and, in papers which we hope will be accepted by the Institute, Dr. Turkdogan and I will give Mr. Oliver his answer.

Dr. A. H. Leckie (B.I.S.R.A.): Some of Mr. Jackson's results, quoted in his list of mixer analyses, should, I feel, be studied very carefully by the laboratory chemists, because there is some very useful information in them. Before I go on to that point, there is another point which I should like to take up with Mr. Jackson. He mentions his experiments with ladle desiliconising. He tried the use of scale in the ladle and had trouble with skulling and getting a messy slag. He also tried oxygen in the ladle, but he has not tried putting in oxygen and scale, as far as I can gather. For the sake of those members of the industry who are not able in their plants to have such active mixers as Mr. Jackson has, I should like to call attention to the experimental work which is going on in at least one plant, and probably others, in this country, where scale with lime and fluospar and oxygen are being used in the ladle with considerable success. Mr. Jackson's paper also emphasises the need for the development of some method for separating slag and hot metal in a cylindrical vessel. Much of the success of any alternative processes of refining must depend on that, and chemical engineers should try to solve that problem. It does not seem to me to be insuperable, if people will get down to it.

Coming to the points in Mr. Jackson's paper which are of special interest to the other authors whose papers are under discussion, I should like to draw attention to the dephosphorisation which has been obtained in the mixer. Certain of the analyses show reductions in phosphorus from 1·5 to 1·2 per cent. The carbon, I imagine, is over 3 per cent, so that in discussing the question of what dephosphorisation can be done in the presence of carbon, I think that the theoretical workers might study some of the analyses of Mr. Jackson's metal and slag—not, perhaps, those given in the paper, which seem to be averages, but Mr. Jackson may be able to give them figures for some of the individual taps, where the degree of dephosphorisation may be even greater than is shown by the averages which he gives in his paper.

Dr. T. P. Colclough (Ministry of Supply, Iron and Steel Division): To-day is a milestone for a great deal of work which people in B.I.S.R.A. have been doing over the last five years, and I am sure that everybody is glad that that work has now reached a stage at which the data collected are precise enough for some practical lessons to be learned from them. I have a reputation, I know, for living in the past, but I must say that this group of papers, difficult as they are to read, has given me quite a considerable sense of satisfaction. Some thirty years ago there was a group of furnace operators and metallurgists who speculated on what did happen in the open-hearth furnace. The explanation which has been given by Dr. Pearson of some of these factors is of considerable help. We all knew by bitter experience that if we wanted to get out our phosphorus we had to have enough lime. We did know that lime was considerably more effective than magnesia. We did know that we should never feed dolomite into the furnace if the phosphorus was sticky; we would always put in some lime instead. We ought to join these papers with the papers which we have had previously on the formation of calcium silicates, because we all know now that it is a combination of lime, silica and P_2O_5 which counts, and the work which was done by the men at Steel Peech and Tozer some ten years ago in publishing their booklet on slag control was of immense value. That could be correlated with these papers.

The discussion was continued by Mr. D. J. O. Brandt (B.I.S.R.A.), Dr. A. W. Richards (Imperial Smelting Corporation, Ltd.), Dr. O. Kubaschewski (National Physical Laboratory), Dr. J. Pearson (B.I.S.R.A.), and Dr. E. T. Turkdogan (B.I.S.R.A.)

In the course of his reply to the discussion, Dr. F. D. Richardson said: The old way of doing these calculations *à la* Schenck was a way which gave the right kind of answer and provided a machine which worked to a certain extent, but since then chemistry has advanced a great deal, and the metallurgists who are being trained and coming forward now are having chemistry taught to them, which is, of course, completely incompatible with the idea of free and combined FeO or other constituents in slags. They can recognise only one kind of FeO, not a free FeO or a combined FeO. If you push the Schenck idea too far you reach absurd situations where you may have to say that 50 per cent FeO, and in some conditions 60 per cent, should be free, and −10 per cent should be combined. The only simple way to represent all these data is in a thermodynamic way so far as equilibria are concerned. It is the limits to which we can go that we are all trying to establish. If you are going to understand them, you must be able to read thermodynamic maps. If you want to find your way about the country you must have an Ordnance Survey map and know how to use it, or else ask someone who has been there before, or, if you cannot read a map, consult somebody who can. There is no other way of representing all these data than by heats, entropies, free energies and activities, and we shall reap the benefit of all this work as the new and young metallurgists who are learning things in this way go into the works, and then they can use in solving their problems the information which we are building up. It will not solve any problem immediately, but it will show them the proper lines along which to think in finding a solution.

I agree with Dr. Pearson about the SiO. I have worked out the pressure of SiO in the system referred to by Mr. Oliver, and it is about 0·01mm. Under strongly reducing conditions it is, of course, much greater. Mr. Evans referred to the roof wearing away due to SiO formation. If there is unburned CO in contact with that roof, as, for instance, if you have a CO/CO_2 ratio of 100/1, the SiO pressure will be 1mm, and with large volumes of gas passing along it could obviously carry away quite large proportions if there was in fact that condition at the surface of the roof. Dr. Leckie referred to the possibility of carbon monosulphide being a desulphuriser at extremely high temperatures. It would not really be of use; you would be up somewhere near the boiling point of iron before it would be effective. The data on CS are not very accurate. It is not just a question of considering the point at which the FeS line cuts the CS line, but of considering the sulphur potential line, which is below the FeS line at 1600 deg. Cent., and which does not rise steeply with temperature.

Dr. Colclough raised the question of the basicity of the slag and the conditions under which carbon goes first or phosphorus goes first. I quite agree that they are obviously very closely tied up. The oxygen-phosphorus or oxygen-alloying-element diagram which I showed earlier showed that for Dr. Bookey's solid-solid line, phosphate, phosphorus and oxygen in iron equilibrium. That crosses the carbon-oxygen equilibrium, so that they are obviously running fairly close together. In conditions where the lime activity is low you push the phosphate line up, and if you have conditions where the phosphate activity is low and the lime activity is high you push that curve down. There is a great deal to be done here. Some years ago some American workers made a very good study of slag-metal equilibrium involving phosphorus with slags rather like open-hearth slags, and we should try to work over those data and assemble them and see what the phosphate and lime activities, or the ratios of those activities, could be in those slags in the light of Dr. Bookey's work.

Mr. A. Jackson, in the course of his reply to the discussion, said: Mr. Cameron discussed the question of sulphur elimination with high slag volumes. We had thought of the possibility of the effect being due in part to the different sulphur contents in the gas, but we could not go right back to blast-furnace gas because we could not get our high slag volume with such a low calorific value gas. We did, however, compare pitch and mixtures of coke-oven and blast-furnace gas, and it did not indicate at all strongly that the difference was related appreciably to the sulphur content in the gas. In Table V of my paper I show the comparative effects of feeding a mixer quickly and not feeding it at all. It is quite apparent there that if there are two mixers using the same type of fuel, one making 320 tons of slag a week and the other 30, where the slag volume is low the sulphur goes out and disappears, which seems to indicate that it is not due to the sulphur content of the gas.

(To be continued)

"TUDOR" AIRCRAFT.—The Minister of Civil Aviation has withdrawn his objection to granting passenger-carrying certificates of airworthiness to "Tudor" aircraft which meet the requirements of the Air Registration Board, provided that the number of passengers carried does not exceed fifty, and that flights over water are routed within 250 miles of the nearest land.

A Design Group in an American Shipbuilding Organisation

(By our American Correspondent)

The Central Technical Department—generally known as CTD—was organised to assist the shipbuilding and repair yards of the Bethlehem Steel Company in questions of design, construction methods and materials, and in handling difficult and unusual engineering problems. Comprising a group of specialists in naval architecture, marine engineering and other technological fields, the CTD has become an important asset to an organisation which builds and repairs practically every type of merchant and naval vessel, and manufactures a wide range of propulsion machinery and marine equipment. The work of the department and some of its achievements are outlined in this review.

THE Central Technical Department of the Shipbuilding Division, Bethlehem Steel Company, had its birth nearly twenty-five years ago at the Quincy Yard in Massachusetts, when a preliminary design group was set up as part of the local engineering organisation. At that time the aim was to improve the facilities for discussing construction projects with shipowners, and to provide the best correlation between important hull and engineering features in the early stages of shipbuilding work. The initial results were so gratifying that the activities were soon expanded beyond their original scope. As the staff grew, the services and facilities available were found to be increasingly helpful to other Bethlehem yards which were not similarly staffed and equipped. This led to the organisation of the group as a separate department serving all yards and being directly responsible to the vice-president of the Shipbuilding Division. The location of the CTD at Quincy, the largest and most diversified of all the Bethlehem yards, gives the staff the opportunity to keep in close touch with the construction of ships of many types and with the manufacture of a wide variety of marine machinery.

The department is divided into two main branches, engineering and design, and development and research. However, the distinction between them is not always sharp, and the functions sometimes overlap. The range and variety of the work, and the large staff required—about 150 employees—have necessitated further subdivision into twenty-eight sections, each including a group of related subjects and each headed by a qualified engineer with years of shipyard experience.

Preliminary Ship Design

The following review of procedure in the assumed case of an American ship-operator considering the construction of a group of cargo vessels illustrates one important activity of the department. After receiving the necessary information about the primary governing features—route, type of cargo, number of vessels, frequency of sailings, port facilities—the staff makes a study of the principal characteristics, deadweight tonnage, cargo volume, machinery, speed, power and fuel consumption. Based on this study, they select what appears to be the most favourable combinations for discussion with the customer. Once the customer has agreed to the preferred selections, small-scale general arrangement drawings—usually inboard profile and decks, showing deck arrangements, holds, cargo facilities and compartmentation—are prepared by the CTD, with a brief description giving the main dimensions, capacities and principal characteristics. At this stage a rough cost estimate of the project may also be made by the Shipbuilding Division and presented to the customer. Possible reconsideration of characteristics to adjust the estimated costs to the prospective shipowner's budget may be necessary at this point.

If the customer should decide to proceed further, the next step is the preparation of general drawings and specifications in sufficient detail to permit a definite quotation and a construction agreement. Such information usually includes preliminary plans of lines ; a midship section ; arrangements showing quarters, cargo gear, deck equipment, holds and tankage ; machinery arrangements, and studies of weight, stability and trim. Model tank investigations may also be started if deemed necessary. The essential characteristics of the vessel, its construction, machinery, equipment, predicted performance, and the tests and trials required are outlined in the specifications.

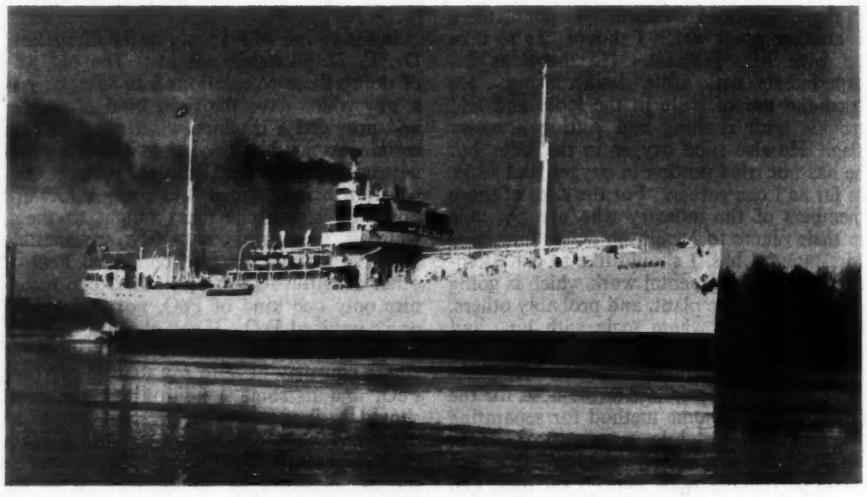
When an agreement is reached to construct the vessels in one of the Bethlehem yards, the next contribution by the CTD is the development of the design and detailed information required by the technical force in the yard selected. Throughout this work, frequent discussions are carried on between the department and the customer to make sure that all plans and specifications have the full endorsement of both. In certain projects, the service furnished to the yard may be even more extensive. In the case of a passenger-cargo vessel, for instance, the work of the department may include development of accommodations and public spaces and collaboration with the customer's representative in matters of interior design, illumination and appearance. Some cases may not involve this procedure, as a customer may have had the preliminary design and the general plans prepared by his own staff or by outside sources. The contribution by the CTD in any particular instance varies with the need of the customer, the character of the project, and the facilities available in the building yard. The department does not, however, prepare the working drawings. This is done by the engineering staffs in the individual yards. The contribution of the CTD in such instances usually includes basic design characteristics of hull, machinery and outfit and, particularly, any unusual feature requiring special attention. This arrangement has proved very flexible, and for each project a division of the technical work is agreed upon between the CTD and the building yard. At any time, however, the shipyard staff may call upon the department for assistance in any development or for review of a proposed construction procedure. Many ship conversions and repairs involve problems which require the service of the Central Technical Department. Some conversions have been so extreme and have so radically changed the functions of the vessel that the CTD has followed almost all of the procedure required in the building of a new ship. A freighter may be converted into a combination passenger and cargo vessel, a tanker may be lengthened to increase capacity, a new bow may be installed to cut down resistance, and new booms may be required for handling extra heavy lifts.

Engineering Service

An interesting function of the department relates to the engineering service section. When a ship has met with difficulties of an unusual nature, the case is referred to the CTD. It may be a problem relating to performance—power, fuel consumption, speed, temperature, pressure ; or it may be storm damage, machinery casualty or unexplained failure of materials. Specialists are available to discuss such problems with shipowners, to visit the ship, and even to go to sea with it if necessary.

The materials section is responsible for advising on selection and specifications of materials, supervision of X-ray and gamma-radiographic inspection of welding on hull and machinery, investigation of corrosion problems, advice on paints and the preparation of surfaces for painting, and the conduct of all chemical tests. Gamma-ray testing was used by the CTD as far back as 1935 to detect flaws in welds and castings, and the department has done much pioneering work in this field. The method soon became an indispensable adjunct in the repair-welding of large castings and forgings, in the assembly of subdivided castings, and in the welding of high-pressure pipe. Later it was supplemented by X-ray inspection and magnetic-powder testing, and all three methods are now in general use.

The CTD has won recognition for its contributions to the advancement of modern marine technology. Although not normally concerned with consultant design work relating to construction in non-company yards, the department has undertaken this work for joint building programmes involving Bethlehem and other yards.



Dry Cargo Vessel Converted into Petroleum Tanker

Two recent examples in this respect are the " Mariner " class of high-speed freighters for the U.S. Maritime Administration and the high-speed twin-screw Fleet Oilers for the U.S. Navy. The CTD has also handled several important naval research projects resulting in the development of new equipment and systems especially adapted to naval use.

Machinery Developments

Generally, the Bethlehem Steel Company endeavours in the construction of a vessel to use standard equipment and auxiliaries produced by outside manufacturers. However, there

are times when these are inadequate for a specific purpose, or when the design of a ship requires products not obtainable from the regular manufacturers. In such cases, the CTD produces its own designs. Examples of such equipment include distilling plants, improved hydraulically operated watertight doors and pneumatic sewage-ejecting systems. Work on an improved distilling plant was started in connection with the construction of a naval vessel where the importance of saving space and reducing weight suggested investigation of possible improvements in evaporator designs. After extensive studies and experiment a new low-pressure design was evolved, which resulted in an evaporator proving practically automatic, easily operated and maintained, and very reliable. Its efficiency is such that a single-effect unit produces 40 tons of fresh water, a double-effect unit 70 tons, and a triple-effect unit 110 tons for each ton of fuel oil consumed. The distilled water is free from contamination and much purer than most water obtained from regular shore sources. This evaporator has now been adopted on practically all steam-driven American naval vessels and is also generally installed on new merchant vessels.

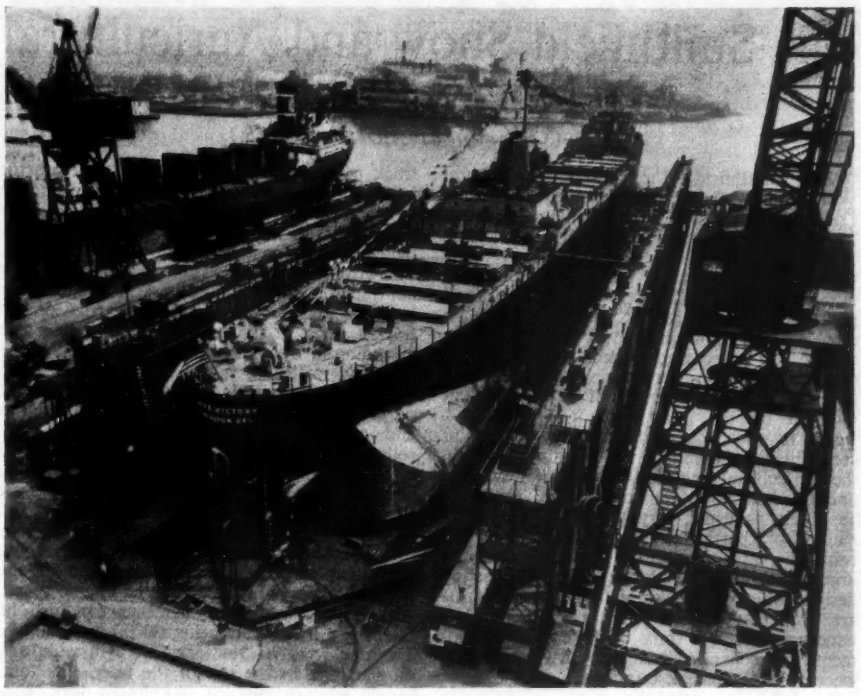
Some years ago the CTD developed an experimental steam plant operating at a pressure of 1200 lb per square inch, in which steam is reheated in the boiler after passing through the turbines. The first vessel equipped with such a plant, the S.S. "Examiner" of the American Export Lines, has proved most successful in operation. Following this, eight large ore carriers, built at the Sparrows Point Yard, were equipped with this reheating feature, using a steam pressure of 1400 lb per square inch. The fuel consumption of these vessels, which are the largest ore carriers in operation in America, is 0·51 lb per shaft horsepower hour, considered to be an exceptionally fine performance for steam machinery on shipboard.

Ship Conversions

A development of particular interest in the United States at this time is the water-borne transport of liquid chemicals in bulk. Bethlehem has converted several ships into such carriers, including the "R. E. Wilson," which originally was a welded tanker. The conversion of the "R. E. Wilson" was carried out at the Hoboken Yard and required the addition of two longitudinal bulkheads extending the full length of the liquid-cargo space, two partial transverse bulkheads, and an inner bottom. This work was done with the ship afloat, ballasted carefully to avoid straining the hull while the strength deck was being cut. Complete new piping and pumping arrangements using special alloy steels were installed to provide nine separate systems for chemicals in the centre tanks and one for petroleum products in the wing tanks.

The increasing consumption of liquefied petroleum gas has led to the development of tankers, by conversion of normal dry-cargo vessels. Two such conversions, "Natalie O. Warren" and "Ultragaz," shown in the illustration, were completed at the Beaumont Yard. This work included the installation of high-pressure cylindrical tanks for the storage of liquefied propane and butane under high pressure. Carefully designed liquid and vapour piping, pumps and compressors and special safety devices were required to ensure economical and safe transport of these unusual cargoes.

Unique in many respects was the conversion of the ocean-going Victory ship "Notre Dame Victory," now the Great Lakes carrier "Cliffs Victory," illustrated herewith, which was described in THE ENGINEER of November 30, 1951. At the Baltimore Yard the vessel was cut amidships and a 165ft section inserted. The existing structure was altered to provide ballast tanks, ore holds and hatches of the type used on conventional lake ore carriers. A new section, built at the Sparrows Point Yard, was launched and towed to the Baltimore Yard where it was joined to the original bow section in the graving dock. Next, the stern section and the lengthened forward section were joined in the 20,000-ton floating dry dock at the yard. Finally, the converted vessel was towed down the coast, up the Mississippi and the Illinois River, and through the City of Chicago into Lake Michigan. A somewhat reversed procedure was involved in the conversion, at the East Boston Yard, of the Liberty ship "Janet Lord Roper" into a collier, the "P. W. Sprague." To fit existing loading facilities, the vessel had to be shortened 30ft. This operation was performed in a floating dry dock, where a section of that length was cut out just forward of the deck house. With the bow secured in place, the dock was flooded to float the stern section. The latter was then moved forward and carefully guided to settle on the keel blocks, leaving it in perfect alignment with the forward section when the dock was again pumped out. Plates and shapes were added to bridge the gap of one frame space in a smooth, strong connection.



Victory Ship Converted into Ore Carrier

Investigation of Ship Failures

Structural failure is a subject which is constantly under investigation by the CTD. A number of merchant vessels built during the last war showed welding failure in service. The department made a thorough and extensive investigation of these failures over a period of more than four years. It included studies of available information on welding failures in ships, as well as a large number of tests and strain measurements conducted both on ships and on representative welded assemblies.

The first year following the war brought a disturbing number of tail-shaft failures on Liberty ships. According to a report by the American Bureau of Shipping, these failures were caused by vibratory stresses resulting from a torsion critical at or near the designed engine speed of 76 r.p.m. The Bureau issued a directive ordering all Liberty ships to reduce shaft revolutions to 66 r.p.m. until corrective measures could be taken to eliminate the vibratory stresses. This, however, meant a sacrifice of nearly 10 per cent in the speed of the vessels. After careful study of the problem, the CTD came to the conclusion that a new propeller with a different pitch could be designed to absorb the maximum horsepower of the machinery at 66 r.p.m., and to recover most, if not all, of the sea speed lost through the reduction in shaft speed. Actual experience on the first ship so equipped more than substantiated this conclusion, and soon a large number of Liberty ships were fitted with the new propeller.

Wind-tunnel tests with various funnel models carried out by the CTD have resulted in the development of an ejection system which gives freedom from the smoke nuisance so common on many ships. The development of the Bethlehem-Frear corrugated bulkheads represents an important advance in structural design. Made without stiffeners, they are considerably lighter than conventional bulkhead assemblies and thus allow greater payloads to be carried. The smooth contour of these bulkheads also provides better drainage in tank spaces, facilitates cleaning, and reduces corrosion. Other important research projects of the department deal with welding practices, the behaviour of ships in a seaway, marine-borer activity, corrosion and fouling, protective coatings, sand blasting, scale removal, noise on shipboard and turbine-blade vibration.

The modern ship is a complex creation. Inherent in its construction, operation and maintenance are many problems for the owner and operator. It is in the solution of these problems that the Central Technical Department of the Bethlehem Steel Company's Shipbuilding Division renders an interesting and valuable service to its customers and to the American shipbuilding industry as a whole.

A Powerful Nuclear Particle Accelerator

WHILE the 3000MeV Cosmotron installation at the Brookhaven National Laboratory, Upton, New York, is only just starting operation, plans are already being made by physicists at that laboratory for a considerably more powerful accelerator which would allow energies of up to 100,000MeV to be reached. In accordance with a theory evolved at Brookhaven, it may be possible to focus atomic particles in flight so that they group themselves in a beam so narrow that they can travel in a tube of relatively small cross-section. The smaller the dimensions of this tube, the less massive the electromagnet required to guide the particles in the circular path of the tube. Projecting this theory to a possible accelerator design, the physicists believe that a 30,000-MeV machine would require a magnet of only half the weight of the 2000-ton magnet of the present Cosmotron, which is designed to produce 3000-MeV particles. The Cosmotron magnet units have a cross-section of 8ft by 8ft, as compared with dimensions of about 1ft 6in by 2ft for a future machine. However, the 30,000-MeV machine would have ten times the 60ft orbit diameter of the Cosmotron and the r.f. system of building up the energy of the particles would be more complex. It is believed that the same methods could be applied to a 100,000-MeV machine, with magnet units of about the same cross section but having an orbit diameter three times larger.

The Smithfield Show and Agricultural Machinery Exhibition

No. II—(*Continued from page 752, December 5th*)

THE Smithfield Show and Agricultural Machinery Exhibition was opened at Earls Court, London, last Monday morning, December 8th, and will close at 7 p.m. this (Friday) evening. Throughout the week there have been many visitors from all parts of this country and from overseas. The exhibits of cattle, sheep and pigs were more numerous than at any of the three preceding post-war shows, and the exhibits on the 350 or so trade stands are thoroughly representative of power farming machinery and implements and of much of the equipment required by the meat trades. The Show—which is now organised annually by a joint committee representing the Smithfield Club, the Agricultural Engineers' Association, and the Society of Motor Manufacturers and Traders—has been, as usual, very effectively laid out, a matter of particular significance this year, being the large number of new machines and implements and new developments of existing design which agricultural engineering firms are displaying for the first time. In our last issue we dealt with some of these new developments in mechanised farming. In what follows we continue those descriptions.

Rotary Hoes, Ltd.

Most of the machines exhibited by Rotary Hoes, Ltd., Horndon, Essex, are new productions. Among them is the "Platypus 30" crawler tractor, which is illustrated in Fig. 9. This tractor, which is built by the Platypus Tractor Company, Basildon, Essex, and distributed by Rotary Hoes, Ltd., was originally designed as a prime mover for the Howard "Rotavator" for work in sugar plantations and in such places as vineyards, coffee plantations and hopfields. It is, however, suitable for the operation of other implements. The tractor is available with either a Perkins "P4" diesel engine or a Standard 3·34in bore petrol engine, the latter being known as the "Platypus 28." The diesel-engined model is the one which is on view at Earls Court; it develops 30 b.h.p. at 1600 r.p.m., the petrol-engined version giving 28 b.h.p. at 1800 r.p.m. Transmission is through a 12in spring-loaded, single dry-plate clutch to a gearbox giving six forward and two reverse speeds. The forward speeds are from 0·8 to 5·1 m.p.h., the reverse speeds being 0·87 and 2·38 m.p.h. The drive is transmitted to a differential to which the steering brake drums and spur reduction gears are coupled. The steering brakes are independently operated by hand levers.

Each track sprocket is splined to a taper axle carried by twin ball bearings, the standard track centre distance being 31in. The tractor has a standard track-plate width of 8in and an over-track width of 39in. The steel track links are fitted with hardened steel bushes, the track plates being of cast steel with integral grousers. The ground pressure on a track of 38½in with 8in track-plates is stated to be 4·71 lb per square in. The weight of the tractor is carried on the track frames, at the rear, by a transverse axle extending in front of both sprockets, and at the front by two leaf-springs. To each track frame there are three bottom rollers, which are carried on bronze bushes with circulating oil lubrication and are interchangeable with the top idler rollers. Adjustment of the track is obtained by varying the position of the front idler, which is spring-loaded and is free to recoil against shock-loading. The standard equipment of the new tractor includes a rear power take-off, the six-spline coupling end of the shaft being 1⅛in diameter. The maximum speed of the p.t.o. shaft is 600 r.p.m. at rated engine speed. A belt pulley, of 24in diameter, can also be fitted, the belt speed being 2000ft per minute. The tractor is 7ft 7in long, 3ft 5½in wide and 4ft 6in high to the top of the tank. Its total weight is just over 2 tons. As already mentioned, the "Platypus 30" has been designed primarily as a prime mover for the Howard "Rotavator," which is now produced in several versions by Rotary Hoes, Ltd. The standard equipment of the tractor therefore includes either a "D" or "F" "Rotavator," the former having a cutting width of 40in, 50in or 60in, the depth of cut being adjustable to 6in, and the latter a cutting width of 38½in, with a cutting depth adjustable to 9in. The drive to the "Rotavator" is taken by a splined shaft which is coupled direct to the tractor's power take-off shaft and thence by chain drive to the rotor carrying the hoes. This rotor is fitted with a dry safety clutch—employing two friction discs—which minimises the risk of damage to the working parts of the "Rotavator" when stony or stumpy ground is being worked. The drive to the "Rotavator" is controlled by a two-speed pre-selector dog clutch.

Another new product on the stand is the 6ft trailing "Rotavator," illustrated by Fig. 10. It is suitable for use with any medium-powered tractor (up to 35 h.p.) which is equipped with a rear power take-off shaft. The implement is hitched to the tractor by a simple pin and clevis arrangement and has a slave hydraulic ram for connection to the tractor's hydraulic lift. The depth of cultivation of the trailing "Rotavator" can be adjusted to a maximum of 8in. The drive to the "Rotavator" is taken direct from the power take-off shaft through a universal coupling and extension shaft to bevel gearing driving a jackshaft, the final drive from the jackshaft to the rotor being by roller chain. All the transmission parts and shafting are enclosed in dust-proof casings and run in oil baths. The overall length of the 6ft trailing "Rotavator" is 11ft 6in and its weight 14¾ cwt.

Rotary Hoes, Ltd., is also showing the Howard trench digger and pipe-layer which has been designed for use with the new Fordson "Major" diesel tractor. The trench digger is mounted on the rear end of the tractor and can be raised and lowered either by a hydraulic ram operated from the tractor pump or by winch and cable, the latter being used also to hold the machine in the elevated position for transport. Power is transmitted through the power take-off shaft via bevel gearing to a heavy roller chain drive and thence through spur reduction gearing to the rotor on which twelve spade-shaped blades are mounted, digging to a maximum width of 9in and a depth of 3ft 6in. Crumb left by the blades is collected by a scoop-shaped scraper blade, which can be adjusted to suit trenches of varying depth. The blades lift the spoil, which is deposited beside the trench and there formed into a ridge by an adjustable mould-board, the sole-plate of which acts also as a depth control. Top and bottom scrapers are provided to clean the soil from the rotor, and there is a rotor scraper to keep the rotor face clean. The tile-layer is mounted on the trench digger scraper blade and requires the services of a second operator to insert the tiles as the machine progresses. The equipment consists of a chute mounted on a suitably constructed base down which the pipes slide. The forward end of the base sweeps any earth deposit remaining in the trench to the sides, and the keel-shaped bottom produces a concave groove in which the pipes are deposited. A cast-iron roller is attached to the rear of the base and as it runs over the pipes ensures their even bedding and correct alignment.

R. A. Lister and Co., Ltd.

On several occasions recently comment has been made about the desirability of more mechanical handling in farming operations. Among the loaders on show at Earls Court are two which have been introduced by R. A. Lister and Co., Ltd., Dursley, Glos. They are 16ft and 24ft general-purpose elevators and a photograph of the latter is reproduced in Fig. 11. The agricultural applications of these elevators include the handling of hay or straw bales, sacks of grain, potatoes or other crops, and loading roots from heaps or clamps into wagons.

In designing the elevators, lightness in construction has been kept in mind and it has been combined with maximum strength and manœuvrability. They are so balanced that one man can move and position them for correct loading and delivery. The 16ft elevator, which weighs about 7 cwt, has a maxi-

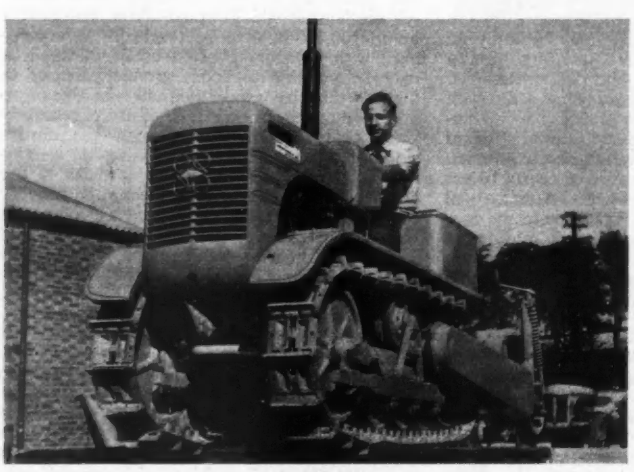


Fig. 9—"Platypus 30" Crawler Tractor—Rotary Hoes

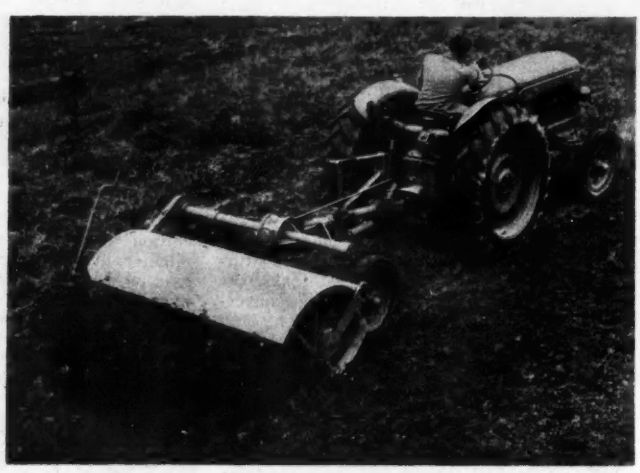


Fig. 10—6ft Trailing "Rotavator"—Rotary Hoes

Fig. 11—24ft General-Purpose Elevator—Lister

mum delivery height of 12ft, while the 24ft machine weighs 10 cwt and has a delivery height of 18ft. The main frames of the elevators are of rolled steel with welded box steel cross bars to give complete rigidity. The moving platform consists of wooden slats bolted to heavy steel-linked chain, which is welded for additional strength. The slats carry the load, rather than push it up, as in the normal "fixed bed" design of elevator. To every third wooden slat an angle iron is fixed which is so designed that it can be modified for the particular lifting job on hand; thus, the angle iron only is required when lifting bales or sacks, but there is an adjustable attachment to it for dealing with loose root crops. Wooden side-boards are fitted to each side of the elevators, but they can be removed quite easily when handling bagged produce. With the side-boards removed, there is, of course, a wider platform available, and the risk of sacks being damaged by rubbing or catching on any projection is eliminated. For raising or lowering the elevator platform there is a mechanically operated telescopic tube, which adjusts the height with little physical effort. A double-acting telescopic tube is fitted to the 24ft machine to give the necessary extra lift and for stability during loading an adjustable telescopic stand has been provided. Drive for the elevators is provided by a 2½ h.p. air-cooled petrol engine; alternatively, electric motor drive can be arranged. The moving platform is started and stopped by a combination of belt guide jockey pulley and clutch and the main drive between the jockey pulley and the platform is taken by two "V"-belts. The platform speed is about 100ft a minute. Although the elevators, as exhibited at Earls Court, are intended for work on farms, their suitability for many industrial purposes will be readily appreciated.

Another new item of Lister equipment at the exhibition is a light-weight portable sheep-shearing set weighing 70 lb. It is mounted on a base measuring 23in by 11in and can be conveniently stowed in—and used from—the luggage boot of a motor-car. The power for the two shearing brackets is provided by a 1 h.p. air-cooled engine.

Transplanters (Robot), Ltd.

Recent developments in the potato planters made by Transplanters (Robot), Ltd., Sandridge, St. Albans, Herts, are exhibited on that firm's stand. In Fig. 12 we illustrate a two-row potato planter, with a fertiliser distributor, which is mounted on a power lift ridger. To arrange this planting attachment satisfactorily above the tool-bar tripod, the planter is in two halves, each half with its own frame which supports the seed and fertiliser hoppers, the fertiliser hoppers being positioned on the outside. The opening plough and the seeding frame are bolted to the underside of the power lift toolbar. The capacity of each seed hopper is 1 cwt and the seed spacing rotors incorporated in the design permit spacings of 12in, 15in, 18in and 21in. The attachment can be adjusted to give row widths of 24in, 26in, 28in, and 30in. The fertiliser distributor will deposit amounts of granular material up to 1500 lb per acre. The fertiliser can be placed in front of the opening plough, at the side or below the potato seed, where it mingles with the ridged up soil. Basically, the fertiliser mechanism is a notched horizontal plate, which conveys the material from the hopper to a delivery tube. The amount of fertiliser deposited is controlled by a slide shutter, which closes the top of the discharge funnel and by a ring shutter around the base of the hopper. As shown by our illustration, the mechanism of the seeding and fertiliser attachment is chain-driven by a sprocket bolted to the rear wheel of the tractor. A spring-loaded jockey tensions the chain whether the planter is in work or raised on the tractor power lift for turning or transport. A hand-operated clutch is used to engage the drive to the seeding and fertiliser mechanisms, and the main drive shaft is situated in front of the power-lift toolbar. The drive is taken by the chain to the right and left-hand secondary shafts, and there are two pairs of bevel cogs on each secondary shaft, which drive the seed spacing rotors and fertiliser mechanism.

The firm is also showing some new versions of its "Robot" two-row and three-row power-lift potato planters, complete with fertiliser distributors. The principal difference in these machines, compared with existing models, is in the material used in their construction. The frames and seed hoppers are of angle iron and sheet steel respectively, instead of steel tubular construction and alloy plate.

Massey-Harris, Ltd.

Two machines only are displayed this year on the stand of Massey-Harris, Ltd., Barton Dock Road, Stretford, Manchester. They are combine-harvesters which the firm has introduced this year. The first of these machines—known as the No. 750—was ready in time for inclusion in the Royal Show last July and was illustrated and described in The Engineer on July 11th. It is tractor drawn, the power for the combine being derived from a four-cylinder side-valve petrol engine developing 25 b.h.p. at a governed speed of 2220 r.p.m. The cutter-bar gives a cutting width of 5ft 6in, and the harvester has a two-speed, six-arm adjustable reel, and a 60in rasp-bar cylinder which is adjustable for speeds from 500 to 1700 r.p.m. The bagging platform on this harvester can be easily folded, which is a particularly useful facility for transporting it along narrow lanes.

The other combine-harvester is the No. 780, which is shown for the first time, and a photograph of which is reproduced in Fig. 13. It is, like its predecessor, the No. 726, a self-propelled machine. Its width of cut, however, is 12ft, compared with the 8½ft cutting width of No. 726. The No. 780 is therefore in many respects a British-made counterpart of the 12ft combine-harvester produced a few years ago by the Massey-Harris Canadian Company. The overall length of the No. 780 is 23ft 5in and its working and transport width 12ft 9in. The thresher incorporates a rasp-bar cylinder, 22in diameter by 32in wide, with eight beater bars, the standard cylinder speeds being 790, 900 and 1040 r.p.m. The combine is equipped with a grain tank having a capacity of 45 bushels, and for the present will be built with that equipment and not with a bagging platform. Power is provided by an Austin six-cylinder, 56 b.h.p. petrol engine, and the speed range—with twenty-four variations—is from 1 to 7 miles an hour.

Bamfords, Ltd.

The exhibits of Bamfords, Ltd., Uttoxeter, Staffs, include examples of the mowers, hay-making and other field and barn machinery which the firm manufactures and also the additions which it has recently made to the "Z" series of direct injection diesel engines. These engines are the "Z2M" single-cylinder, 5½ b.h.p. engine, the "Z7" twin-cylinder, 14 b.h.p. engine, and the "Z8" twin-cylinder, 16 b.h.p. engine (Fig. 14). In the twin-cylinder models pressure lubrication has been introduced for the main bearings and valve gear, the big ends being lubricated by dipper. A factor which makes for simplicity in servicing and ease of maintenance is that all the main components—pistons, connecting-rods, valves, liners, main

Fig. 12—Potato Planter and Fertiliser Distributor—Transplanters (Robot)

Fig. 13—Self-Propelled Combine Harvester—Massey-Harris

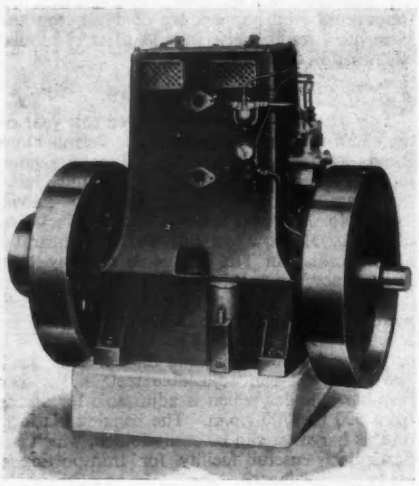


Fig. 14—Twin-Cylinder, 16 b.h.p. Diesel Engine—Bamfords

bearings and governor are common to both the single-cylinder and twin-cylinder models. All the engines incorporate the makers' totally enclosed, detachable governor unit and hinged crankcase.

A lighting set, which is being shown by Bamfords, Ltd., for the first time, consists of a 220V, 3kVA, single-phase alternator with remote controlled starting, powered by a "Z4" diesel engine developing 8 b.h.p.

Among the field machinery displayed by the firm is a new elevator loader which has been designed primarily for handling grass crops for silage or drying. As illustrated by Fig. 15, it is an endless conveyor machine with an all-welded chassis and frame. It is mounted on and driven from pneumatic-tyred road-wheels, a slipping overload clutch being incorporated in the main drive to the conveyor. The loader has a pick-up width of 5ft and the tines on the pick-up drum are closely spaced to give the best

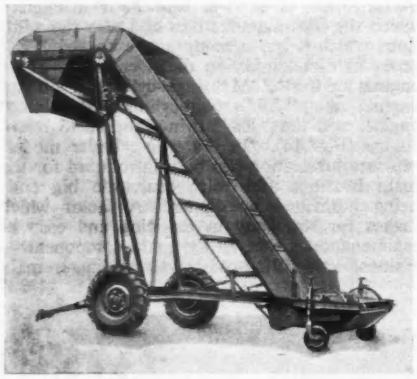


Fig. 15—Elevator Crop Loader—Bamfords

possible performance with short crops. The delivery chute and elevator top are well shielded to protect the gathered crop from the wind.

Another new machine is a combined side rake, swath turner and tedder, which has been produced for use with a tractor and to handle two 5ft swaths. The machine has four rake bars, which are each fitted with removable centres for swath turning. Its frame is of welded and channel construction and there is a single-piece main axle driving through individual pawls in each road-wheel.

(To be continued)

AIR FERRY SERVICE.—The Minister of Civil Aviation, after considering the recommendation of the Air Transport Advisory Council, has approved until December 31, 1961, an extension of Silver City Airways' permit for a vehicle ferry air service between Southampton and Cherbourg to allow the carriage of passengers not accompanying vehicles and supplementary freight.

The Cross Channel Cable

By J. H. M. SYKES

RECENTLY the Minister of Fuel and Power announced that a committee of experts drawn from the British Electricity Authority and Electricité de France had found that it was now practicable to install a cable across the English Channel to connect together the electricity supply networks of Great Britain and France. Subsequent information has suggested that such a cable connection would cost about £4½ million, and that this cost would be shared equally between Great Britain and France. A sum of £250,000—again shared equally between the two countries—has been allocated immediately for development work.

The initial plan is for a cable of a capacity not less than 100MW to be operated at 132kV. Four single-core cables, spaced at a distance of about 1000 yards from each other, are to be laid. The original copper cross section of the conductors was to be of the order of 0·25 square inch, but it is understood that consideration is being given to the use of a larger conductor, possibly double this area. In this case the capacity of the transfer link would be increased. Limitations in the capacity of the French transmission network in the extreme north, at the present time, are to some extent responsible for the relatively small size of the initial link.

Although the Swedish power authorities have embarked on the construction of the world's first high-voltage direct-current link, to convey hydro-electric power from the mainland of Sweden to the island of Gotland, 62½ miles off the eastern coast, it was not considered that sufficient experience had yet been gained in the design, construction and operation of high-voltage mercury arc rectifiers to warrant the construction of a high-voltage direct-current link across the Channel. Thus the initial power transfer will be carried out on the three-phase, 50 c/s alternating-current system, but it has been suggested that facilities will very probably be made available for an experimental direct-current link using the fourth (or spare) core and a sea water return, as in the Swedish installation.

It is likely that the first power transfer between England and France will take place in 1956.

The purpose of the cross-Channel cable is to provide a logical extension of the principle of power network interconnection, which has been the characteristic feature of all power system extension in the more highly industrialised countries of the world in the last two decades. In Great Britain the grid system was inaugurated in 1927 and was in full working order by 1932. Since then it has been steadily expanded, and it has been found necessary to superimpose on the original 132kV system a 275kV super-grid to enable the benefits of grid operation to be still further enjoyed. The same picture has been seen in France, where the necessary joining together of the sources of water power in the Alps, the Pyrenees and the Massif Central to the industrial north, with its heavy load demands, has meant that interconnection on a national scale has been imperative for many years (see map). A 380kV super-grid is under construction in France, and it is of interest to note that parts of the British 275kV super-grid are also to be constructed for future 380kV working. In the U.S.A. the vast extent of the country has meant that no national grid has yet been instituted, but there are a large number of very considerable interconnected power pools, whose high voltage networks are being continually extended, and coast-to-coast interconnection is, in the opinion of some American engineers, inevitable in the near future.

The benefits of grid operation, in brief, comprise first the reduction of idle capital in the form of standby plant, and also the need for less total plant, since interconnection implies diversity of loading, and sufficient generating units need only be provided to deal with the simultaneous maximum demand on the whole system. Increased security of supply is assured, as each load point has at least two feeders and may have as many as six or eight. Possibly taking pride of place among the advantages of interconnected operation is that of reduction of the total costs of generating the whole of the electrical energy needed by the nation or area to which the grid system applies. This element is strikingly demonstrated by a comparison of the spare plant installed on the British grid system in 1926 (the last pre-grid year) and that employed ten years later. In 1926 70 per cent of the total capacity was regarded as spare or standby, and in 1936 this figure had fallen to 26 per cent. The cost of generation, including capital charges, was reduced from 0·4d. per unit to 0·19d. over the same period. In spite of very great rises in coal and labour costs, since that time, the extended use of grid operation principles has meant that the cost of electricity has risen to a much less degree than that of other public services and essential commodities.

With these advantages in mind, it is logical to consider the extension of the grid principle of operation, i.e. by reaching out to encompass the largest number of power generating resources and diverse loads, as widely as possible. The intervention of a 22-mile wide strip of water is an obstacle only in the physical sense of necessitating the laying of a longer submarine power cable than has hitherto been attempted; from the point of view of operation of interconnected systems, the experience gained in Great Britain—and especially in France, where for many years the country has had electrical interconnections with all her neighbours—will mean that no major obstacles to efficient and satisfactory operation should be encountered.

In France, the plant position at the end of 1951 showed that 5843MW of thermal power plant was working in conjunction with 6784MW of hydro plant, thus providing a total plant capacity of 12,627MW. In Great Britain, the corresponding figures at the end of March, 1952, were 14,214MW of steam plant, aided only by 185MW of surplus water power plant capacity from Scotland. To the French plant capacity must be added a certain amount of incoming energy from the interconnectors with Germany, Switzerland and Italy and thus the plant capacity in the two countries is of the same order.

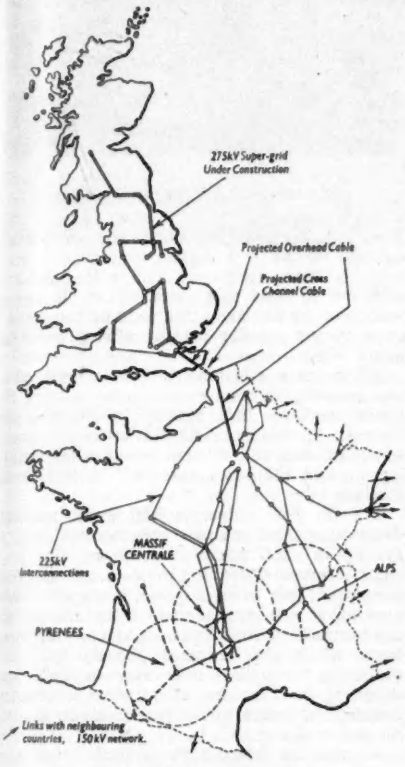
There is, however, the vital factor that the hydro-electric plant in France can give the possibility of much more efficient operation of the British thermal power stations, since in summer when droughts may occur in the catchment areas, surplus steam plant capacity in Great Britain could be employed to export power to France; while in the winter months stored water could be released, at off-peak periods, to conserve coal in Great Britain and to aid in meeting the peak demand.

The diversity in national peak periods between the two countries is of the order of one hour, due partly to differences in Continental time and partly to different working and domestic habits. The possibility of loading up the large generating stations now being built in the East Midlands and central coalfield areas in Great Britain, and containing in some cases a number of 100MW generating units, during the valleys in the annual load curve is an attractive one, particularly when it is realised that coal may actually be saved this way. An increase of 0·1 per cent in the overall British national figures results, in itself, in a coal saving of 160,000 tons a year; and with the highly efficient generating plant of the near future, this gain in the national figures by better loading conditions should be relatively easily attainable.

In France, export and import of current during 1951 resulted in 683 million units passing in and out of the country's frontiers, but only a relatively unimportant export of 3,000,000 resulted from these transfers. This is sufficient answer to those who fear that Britain might become electrically dependent on France, when one or more Channel cables have been installed. The gain in efficiency in both countries could greatly exceed, in terms of annual generating costs, the capital charges on the cables themselves.

It is, of course, obvious that until a link of at least 2000MW—in relation to two systems each of about 15000MW in size—can be established, that there will be little opportunity for large-scale savings in operating costs.

The cable itself involves a number of technical problems, the first being the choice of insulation and the medium for preventing voids. Telecommunication cables for great distances have been constructed of polythene. This material has been used for power cables up to 11kV with success and insulation levels of the order of 350kV per centimetre—approximately the figure used for paper cables—have been found to be practicable. The great advantage of this type of cable is that the dielectric is almost completely water-resistant. The size of insulation needed for a 132kV cable may mean, however, that it is not yet possible to guarantee



Cross-Channel Cable Link

that the displacement caused in the polythene cable during heating and cooling cycles will not result in the formation of voids with subsequent breakdowns. It is, however, thought that future submarine power cables may employ a form of polythene for the insulating element. The alternative to the polythene insulation successfully used for submarine telecommunication cables is that of employing a paper-tape dielectric as used in normal power cables on land. With paper cables for high voltage it is necessary to use either oil under pressure, or gas—usually nitrogen—to prevent the formation of voids when the lead sheath expands beyond its elastic limits and then does not return to the same shape on cooling. The oil-filled cable has been successfully operated at very high voltages, well in excess of 132kV, but the necessity to provide oil expansion equipment at an intermediate point at this long length of cable is certain to rule it out for the cross-Channel project. Thus, gas pressure will be used.

Gas pressure is applied either externally to the dielectric, as in the compression cable in its various forms, or else internally. Either system could be used for the Channel cable.

Three basic methods are conceivable for laying the cable. The first is manufacture in one continuous length, which could then be coiled into the hold of a cable ship and paid out, as in submarine cable practice. The second is the manufacture of a number of pieces, as lengthy as manufacturing facilities permit, which would be laid out and jointed there, as the cable was dragged out to sea, after each joint had been made. The third method is to manufacture somewhat shorter lengths and then to make the joints on a ship as each length was paid out.

The problem of impregnation of the dielectric is difficult when long lengths are considered and therefore the pre-impregnated type of cable, in which complete impregnation is carried out before lead sheathing takes place, is that which is likely to be used for the Channel cable.

Among the few installations which are in any way comparable, the 3½-mile link across the strand between Sweden and Denmark has been carried out using the Mollerhøj oil-filled flat cable, with flexible joints. This installation employed a method of laying based on experience gained in the actual path of the cross-Channel cable, when the Pluto pipelines were laid between England and France during the war years. The large floating drums employed for that project were adapted for cable-laying and a drum 13ft in diameter and 20ft long towed by a tug through the medium of an angle iron framework was employed. This may be the method which will be used for the Channel cable, although experienced sailors, knowing the vagaries of wind and tide in the narrow seas between Dover and Calais, may well anticipate severe difficulties in manœuvring a heavily-loaded drum of this type, if severe sea conditions suddenly arise. Jointing, too, may be difficult if a ship has to remain stationary in the busy Channel waters for perhaps a week or longer, while each joint is made.

The shore ends of another comparable installation—that between the mainland and the Isle of Wight—were very heavily armoured to prevent damage as the cable passes over the rocky shores at both ends : and for this 33kV, three-phase cable of 0·25 square inch conductor section, the overall diameter with the special rock armouring reached 5·96in. With a greater diameter than this handling difficulties would be extremely severe. Thus, consideration is being given to a scheme whereby the shore ends of the Channel cable might be taken out to sea for some distance at each end on lattice steel pylons, erected on piles, out from the shore, so that the cable could descend vertically into deep water.

Other problems which will have to be solved concern the sheath losses in single-phase cables, widely separated. To minimise these, the armouring will obviously have to be of the non-magnetic type, but in spite of this it may well be that these losses will reach relatively high figures. A Dutch submarine cable installation in which single-core cables were used, was designed so that an additional concentric conductor layer of equal copper cross-section to that of the conductor itself, and situated just below the lead sheath, was provided so that a low conductivity return path for the induced currents is available. If this solution is adopted for the Channel cable, it may facilitate the ultimate adoption of high voltage direct current, as the return path so formed would be even better from many points of view than using the sea water.

Allied problems include the possibility of external magnetic fields causing disturbances to ships' navigational equipment and to such devices as echometers and naval equipment for the detection of mines.

The operation of an alternating-current cable of this length is subject to various system stability problems. First and foremost is that of charging current. Figures given in the Electrical Research Association's report B/T 111 show that a 132kV cable is likely to need 2000kVA of wattless charging current per mile. For a distance greater than about 35 to 40 miles it would not be possible to supply this current from the ends of the cable alone and, therefore, intermediate compensation equipment would have to be installed. This is obviously scarcely possible for the cross-Channel cable. Consequently, the system will be working fairly near the limits of stability and in any case compensating equipment will be necessary at one or both ends of the cable.

The possible future use of direct current will mean that a considerably greater voltage can be used ; and in fact the equivalent direct-current kV between lines for 132kV between phases a.c. is 400kV. Thus, direct-current operation of the four cores of the initial cross-Channel link would mean that four to five times the power transfer capacity would be available. Moreover, the firm power capacity of an alternating-current link has to be secured at the expense of laying a fourth core. With direct current, half the firm power on a two-conductor link can be obtained at any time by using the sea as the return ; and with four conductors available, two links could be utilised with each one giving half its firm power, if a single core were to fail through damage, for example, by a ship's anchor. Other advantages which may accrue if the cables are all converted to direct-current working concern the limitation of power flow to a predetermined figure at all times, no matter what may be the frequency conditions on either one of the alternating-current networks which it joins together. This feature may be valuable to the operating engineers, since very large power swings might possibly take place in a partially uncontrolled fashion, if very severe frequency changes were experienced on either of these large networks.

The present trend in very many parts of the world is towards reaching out for distant sources of water power ; and these long transmission projects frequently involve the consideration of crossing the sea or a very wide river estuary. The cross-Channel cable will be the longest submarine power cable in the world and will have the greatest power transfer capacity. The experience gained by British telecommunication cable makers in manufacturing and laying many hundreds of thousands of miles of cables should be sufficient to ensure the success of this pioneer project, which will be watched with great interest by other transmission engineers who have similar problems to face in other parts of the world.

Oil Terminal at Canvey Island

To provide additional storage and distributing facilities for petroleum products the Regent Oil Company, Ltd., is constructing a new ocean terminal with a capacity of about 60,000 tons at Holehaven, Canvey Island. This project was decided upon because the growth of the company's business and the increasing demand on public wharfingers' storage had made the existing arrangements of employing hired storage on the Thames and Medway inadequate. Another factor was the greater demand for aviation fuels which require special storage and handling arrangements.

The installation is being built adjacent to that of London and Coastal Oil Wharves, and, by agreement, it is planned to integrate closely the operations of the two storage plants, it being possible to effect transfers from one to the other. The site occupies an area of about 30 acres upon which some twenty-five tanks, varying in capacity from 500 to 4000 tons, are being erected. This quantity will be contained in two main reinforced concrete bunds subdivided to limit the storage capacity in any one bund to a maximum of 10,000 tons. Ring fire mains, supplied by four pumps, of 2000 gallons per minute total capacity, and drawing water from a 1,000,000-gallon capacity reservoir, will surround the site. Normally, the reservoir will contain fresh water, drainage from the site discharging into it through interceptors. Any excess of water can be discharged through sluices into the river and, in the event of the water being used for fire fighting, the reservoirs can be refilled at high tide by opening the river sluices.

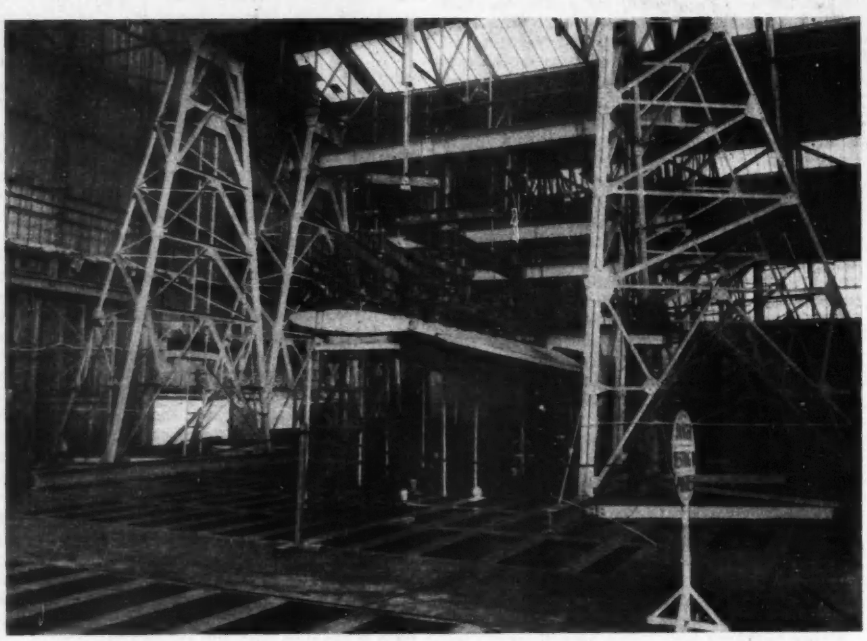
Oil tankers having a capacity of 30,000 tons will be handled by the installation, and for this purpose a jetty is under construction which will provide a deep-water berth having about 40ft of water at low-water springs. Another jetty is being built for berthing barges and coastal tankers. Both jetties are of steel box pile and reinforced deck beam construction with prestressed decking and the tee head of the tanker jetty will have shock-absorbing fenders.

Work on the project commenced at the beginning of the year and satisfactory progress has been made on both the shore and marine construction programme, so that it is expected that the installation will be ready for service in 1953.

An Airframe Test Rig

Some details are given in this article of a structural test rig stated to have a capacity larger than any installation except those installed at the R.A.E., Farnborough. The reasons for its construction at Belfast and an account of some tests on the "SA/4" jet bomber are included.

WHEN, after the war, the entire organisation of Short Brothers and Harland, Ltd., was established in Belfast, Northern Ireland, the problem had to be faced of providing a research unit, capable of handling all the structure testing problems connected with the development of modern aircraft, in order to overcome the difficulty of the transport of large airframe structures to the Royal Aircraft Establishment. Discussions produced the idea of designing a portable structure for the testing of airframes with wing spans of up to 200ft and to accommodate other structural components.



General View of Gantry

The structure which was erected is shown in our illustrations. It comprises a 300-ton grillage of 16in by 8in rolled I-section joists covering an area 200ft by 90ft, resting on a reinforced concrete floor and capable of withstanding a bending moment of 24,000 tons-inches. Set on this grillage are open-braced triangular pylons, each portable with a variable height up to 28ft, and stressed to carry a compression load of 20 tons.

Resting upon each pair of pylons, to form a loading gantry, is a 32ft cross beam which can take a load of 30 tons at any position along its length. This structure is for fuselage and wing testing, and at one particular time during the "S.A./4" test programme, it accommodated both the wing tip-to-tip specimen of 109ft span and the fuselage 102ft long. Other rigs have also been built for the testing of all kinds of components. Every rig is clamped to the grillage during testing.

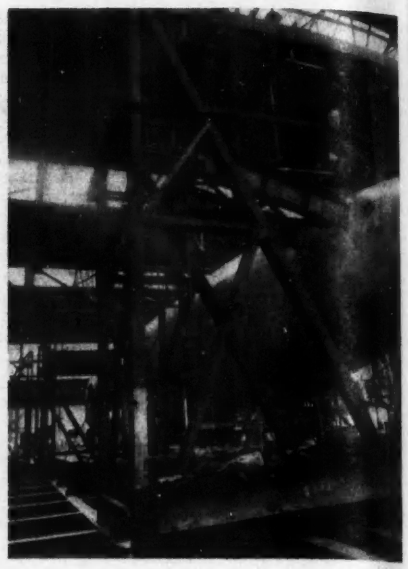
The conception and design of this rig was entirely new, and it is stated to be still the only one of its kind in the United Kingdom, and with no past experience or precedence to back it its first assignment—the testing of the Short "S.A./4" four-engined jet bomber—was undertaken with complete success.

Security forbids a complete description of this test programme, but some details of the main structural test specimens and the engineering of the test rig can be released.

Two mobile cranes were needed to lift the fuselage of the "S.A./4" on to a special sledge sitting on the grillage, which was then traversed across to the actual testing site. Dummy stub wings were jacked on each side of the fuselage until the wing root attachments were made. The fuselage was then lifted from the sledge, slowly raised to the required testing height by jacks placed under the stub wings and the side portal frames manœuvred until they were on a level with the tips of the stub wings.

The design of the dummy wings and their attachments was a matter for special consideration, and it was arranged that the stub wings should have the same flexural axis position as the actual aircraft wing.

The method of connecting to the side frames is shown in our first illustration. To maintain satisfactory stability pin-ended links were used, two placed vertically on each side, to react the vertical sheer and the pitching moment; one placed horizontally on each side to provide against yawing; a further pin placed horizontally athwartships on one side only was sufficient to react side sheer. Thus the centre section of the fuselage was able to be constrained in a manner similar to that arising from the actual wings.

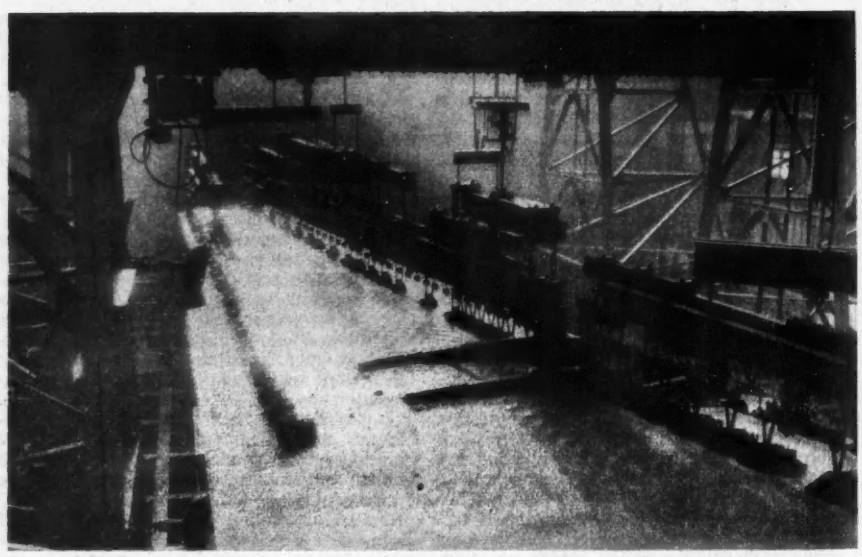


Arrangement for Fin and Tailplane

When these attachments were completed it was possible to remove the jacks, leaving the whole specimen held entirely by the two side frames. In this position the bomb doors and structural steel dummy nose wheel undercarriage leg, fin and tailplanes were all attached to the fuselage.

The fin and tailplanes had been specially designed so that a single concentrated load at the tip of each would give the required root sheer torque and bending moment, but in order to support the tailplane and fin loads when applied, it was necessary to erect around the tail unit a large load reaction rig carrying jacks upon which the tailplane rested, and also mounting the pulleys over which a load, produced by dead weight, would serve to counterbalance the weight of the rear fuselage, dummy fin and tailplanes.

At the commencement of the testing programme the fuselage was first subjected to a proof loading representing a landing case, and governing the forward part of the fuselage and centre section. In this test the main loads were a vertical and side load on the nose wheel under-



Linkage Detail

Bomb Door Test

carriage leg, the remaining loads being inertia effects. The fuselage was then tested to destruction, under conditions arising from yawed flight, by applying major loads on the tailplanes and fin in the form of a large down load on one tailplane, a smaller down load on the other, and a large side load on the fin. Once again the remainder of the loading was for inertia effect and the results of this test governed the rear fuselage and the centre section.

Erecting the wing tip-to-tip specimen, which was complete with a portion of the fuselage, carrying the centre section, was an even bigger task. To place this in the test site, the loading pylons and cross beams were first positioned and the two wings separately traversed between them by using a shop trolley with its wheels running in channel sections laid as a railway on top of the grillage. When each wing was in its correct position it was lifted from the trolley by a hoist from the overhead cross beams. Then the portion of fuselage which, with structural steel and frames attached, lay on plates on top of the grillage, was manœuvred through the pylons to its position between the wings and clamped to the grillage.

After each wing had been attached to this portion of the fuselage, the whole specimen was raised to the required height by jacks positioned under the end frames. Here again particular attention was given to providing representative conditions in the fuselage.

From each of the end frames a braced pyramidal structure was built which terminated at a universal trunnion fitting attached to the grillage by a vertical pin-ended member. This was the support at the rear end of the fuselage for all tests, but the front trunnion was held in the fore and aft directions as well, when testing landing conditions, in order to react drag loads. Once these attachments had been made, dummy engine and undercarriage loading structures were secured in position.

The process of assembling the overhead wing loading linkages, which followed the accepted standard form, commenced. The method of arranging these was first to assemble them on the hydraulic jacks away from the specimen and, after balancing, move them along the cross beams until they reached the required position, finally clamping the jack trolley to the cross beam.

In all, three tests were conducted on the wings. The first was a take-off loading to proof conditions, the second a landing case to proof conditions, and the final test, that of a flight case to destruction.

The special rig constructed for testing the bomb doors is shown in our illustration above. Being a smaller component the need for individual pylons was not present and so the loading structure was built as a single unit, clamped securely to the grillage, to which a normal linkage system was attached. In this case, however, the actual attachment of the linkage to the bomb door specimen was made through pads of sponge rubber stuck to the surface, a method of loading which permits any wrinkling of the thin skin to take place with the least possible constraint at loading points.

In the past, testing rigs constructed as single units have necessitated the design of new structures for each new shape of wing under development, but with this structure the shape, size or position of the wing does not matter.

The Harrogate Dam Failure *

By DELWYN G. DAVIES, B.Sc.(Eng.), M.I.C.E.

THE open service reservoir at Harlow Hill is rectangular in plan, but quite small, and unimportant dimensionally, compared with the great structures usually discussed in engineering institutions. Holding 14 million gallons of water, it lies perched on the hill (550ft O.D.) with embankments on three sides, north, east and south, some 230ft immediately above the town it serves. Between the reservoir and the town centre, a distance of about a mile, stands a continuous belt of good residential property. The dam, constructed eighty-three years ago, consists of a "normal" earthen embankment with clay core supported by "selected fill" and a maximum height of 29ft above natural ground level at the junction between the east and north embankments. The upstream and downstream faces have a slope of 1 in 1·9, terminating at the eastern downstream toe with a 4ft concrete retaining wall contiguous with the public road. Two separate draw-off pipes, one with a valve tower, pass through the embankment some 4ft and 7ft below top water level. The reservoir has been twice inspected and approved under the Safety of Reservoirs Act, 1930.

One week before Christmas Day, 1951, following an extremely wet autumn, a major downstream slip was discovered where the dam is highest, on the eastern embankment near to its junction with the north embankment. A vertical movement of 12in on the suspected slip plane had already taken place adjacent to the core wall, whilst the toe had uplifted about 9in against the retaining wall. Unfortunately the slip was still on the move at a rate of about ¼in per hour. In plan, the slip was elliptical with a short axis, from the toe wall to the crest of the slip, of 53ft and an eventual contour axis length of 80ft. Immediate emergency measures, therefore, were imperative. It was feared that in such a position the two embankments, east and north, might separate, cleave the puddle wall at the corner, and debouche the store of water across the road into the residential property below, before accumulating in the town centre. At one time this situation appeared possible.

Four immediate actions were taken, namely :—

(*a*) The water in the reservoir was lowered as fast as possible.

(*b*) Sandbags were filled from the filtration sand store and other sources, and loaded on the toe of the slip in an attempt to restore its equilibrium.

(*c*) Further lubrication of the slip was prevented by protection with tarpaulin sheets against rainfall.

(*d*) Simple gauge-points were fixed across the slip and at intervals along the high east and adjacent north and south embankments, to detect and measure further movements.

By working night and day for 200 hours, continuously until late on the ninth day (Boxing Day), a total of 33,000 sandbags had been filled, together with some 400 tons of loose sand contained in the pavement buttresses. As the reservoir water level dropped, difficulties were increasingly experienced in maintaining supply. Thus, the old 9in washout pipe through the embankment was connected to the distribution mains to help meet these difficulties. It was possible that this pipe either had been or would become disjointed by embankment movements, but there was little choice if a continuous supply were to be maintained. The two existing draw-off pipes were now poised in mid-air above the water. In consequence, the entire output of the filtration works (except that passing through the wash-out pipe) was by-passed around the reservoir straight into supply until the draw-off pipes had been converted to siphon outlets by the installation of small vacuum pumps.

During the failure, the birth and development of a major slip in a clay embankment was studied. Its first stage consisted of a change in the straight batter of the embankment, a perceptible bulge showing two-thirds of the way down the bank. The bulge was shown much more clearly by shadows from flood-lighting down the embankment after dark. This was followed by a small crack formation just below the top of the batter, and this crack gradually extended along the contour, curving down the embankment to disappear in the slump of the lower half. These cracks, first beneath the soil and then later through it, were detected by fixing two posts with "U"-shaped top sockets, one near the top of the bank and one 20ft down, across which a metal tube of sufficient cross-section to eliminate sag, was placed. The tube rested against the socket of the bottom support and was free to slide within the "U"-shaped top socket. As the inclined tube was clearly marked near the top, any downward movement created by separation of the structure was detected.

Trial holes and borings proved that the major slip plane possessed a thickness of ¼in of "porridge" clay and was curvilinear on both axes. The amount of moisture required to maintain the lubrication of the slip was very small. Although a total of one major and four incipient slips occurred, none was contiguous with another. Reasons may be advanced why a gap must exist between one slip and its neighbour. The slips in closest proximity were those at the corner of the reservoir, where the embankment is highest. The stability influences of a right-angle corner in an earth dam are probably dangerous.

The only large stony material (2in to 6in boulders) in the embankment was found at the top of the major slip below the soil. It is questionable whether this had been deliberately placed along the contour for 10ft as a drain, but there is no doubt that it contributed to failure by acting as a reservoir to feed concealed shrinkage cracks.

*Abstracts. Institution of Water Engineers' Winter General Meeting, December 5th.

The structure was, by Victorian standard, well constructed. Recent trial pits disclosed a well-compacted dense clay core. The selected fill was transported by horse and cart and tipped into place. The methods of consolidation employed are unknown. It appears that clay may have been deliberately used in the selected fill, not merely to support the clay core, but also to provide an additional line of defence against penetration by water. The dam was founded on a deep layer of clay, but investigations revealed that the surface soil had not been removed before the embankment was constructed.

About 1900, the old bridle path at the toe of the embankment was converted into a public road. In so doing, about 10ft of the toe of the embankment was removed and replaced by a "sturdy" concrete retaining wall. A 4in stoneware toe drain was laid at the upstream side of the wall and the trench closely packed with clay fill, ostensibly to prevent any downstream movement of the embankment.

The 4in diameter stoneware drain had delivered a reasonable flow of water varying consistently with the intensity of the rainfall, from 3 g.p.m. down to almost zero. This suggested that all was well with the drainage system. In actual practice, however, the drain was fed by 2in tile drains at 20ft centres, each draining shallow rubble drains built at similar centres down the embankment. As the 4in stoneware drain and the branch tile drains were wrapped in dense clay there was, therefore, no proper means of draining any water which had collected *within* the clay fill.

The downstream and upstream slopes of the embankment were constructed at too steep a batter for the material employed. From the soil tests carried out, this material would require a batter of at least 1 in 3½ instead of 1 in 1·9 to be stable under all weather conditions. Without an internal investigation of the material within the structure it would have been impossible to determine its factor of safety. Indeed, a visual examination of the embankment before the failure would have enabled the great majority of engineers to give it a clear bill. Even if soil tests had been taken during a normal summer and near the surface, the embankment would have been classed as stable. Comparative shear tests of material below the 3ft capillary fringe, and to 8ft depths, revealed a 50 per cent improvement in seven months.

There are two distinct beliefs on the effect of age on the stabilisation of dams, particularly earth dams of clay. There are those who consider that owing to natural consolidation, an earth dam gradually improves in strength and shear resistance and therefore its factor of safety rises. However, after final consolidation is reached, the structure imperceptibly weakens year by year. The "adult" weakening takes four distinct forms :—

(*a*) Severe drought shrinks the clay fill, the shrinkage proceeding in a downhill direction. During drought the deepest point of the water table below the surface will occur below the top of the downstream batter.

(*b*) These activities are accentuated by the gradual creep downwards of the surface soil towards the toe. In time this creep causes small tension cracks in the upper parts of the batter and these cracks allow rain water to enter the clay shrinkage cracks.

(*c*) Within the clay core, the slow movement of water passing through it gradually takes out of solution any salts in the clay, possibly by a very slight base-exchange process. The top part of the clay core suffers successive drying and wetting, as dictated by the frequency of drought and rain, and the degree of use to which the reservoir is put.

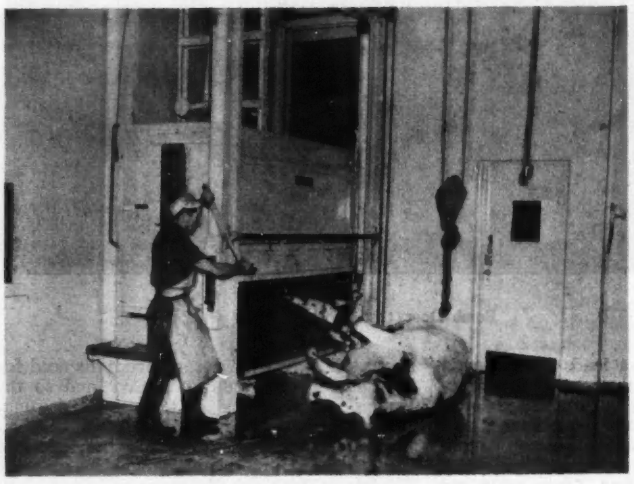
(*d*) The drainage system declines in efficiency.

Vertical contour cracks are therefore inevitable at the top of a downstream slope of any material which shrinks with declining moisture content. This theory was confirmed when a trench cut through a stable part of the embankment disclosed vertical contour cracks below the soil at the top of the downstream batter.

The initiating causes of the Harlow Hill dam failure were undoubtedly (*a*) and (*b*). There was no evidence that the clay had been weakened by base exchange or that the drainage system had declined appreciably in efficiency.

An Experimental Slaughterhouse

WE were recently invited to visit the Government experimental slaughterhouse which has now been completed near Fareham in Hampshire. This slaughterhouse is one of two (the other is at Guildford) which have been built by the Ministry of Food for experimental and demonstration slaughtering, as well as to provide rather urgently needed modern facilities. The premises have been designed to try out "line dressing" on a scale suitable to conditions in this country, with a single dressing line for cattle and a line for "smalls" (i.e. calves, sheep and pigs). The capacity is about 120 cattle and 500 to 600 "smalls" a day, but one of the objects of the layout is to find out from experience what is the maximum capacity of a single line, when manual handling is reduced to a minimum, and the most logical sequence of dressing and layout is adopted.



Ejecting Stunned Animal from Shooting Box

Thus the building is laid out with a shooting box for cattle at one end of the slaughter hall (there is also a stunning box for kosher meat), with a cattle race leading to it in the lairage adjacent to the hall. The shooting box is shown in the illustration above. The animal is admitted from a door at the back of the box, and its head is then held still in a yoke, facing the small door at the front of the box, while the operator shoots it with a humane pistol. The body is then ejected at the side of the box, as shown in the illustration, and hoisted on to the dressing line, where the various dressing operations are carried out successively. At appropriate points certain organs and materials (fat, tripe, gut, hides, &c.) are removed either to chosen rooms or by elevators to the first floor gut and hide rooms. The red offals are suspended in sets from rails which run parallel to the dressing rails. One of the last operations in the line is shown in the illustration below, where the carcase is split with a power-operated saw. The saw is carried on a mobile tower ; the operator stands on the platform shown, which travels downwards as the sawing progresses. After this process, the carcases are cleaned and put in the chilling rooms. At the opposite end of the slaughter hall similar facilities are available for the smaller animals. Thus the complete layout shows a flow of edible meat and offals (excluding tripe) from the stunning pens to the cooling rooms, with all other materials moving laterally, so that no contamination takes place.

No provision has been made to process by-products. The aim has been to arrange that the by-products will be handled in such a way that they can be sent to processing plants without deterioration in condition. One distinctive detail is that the stomach contents go direct into a special hopper where drainage takes place ; since the contents are sealed off in this hopper they cannot contaminate any material in the premises.

Structural Design

The slaughterhouse was originally designed with a reinforced concrete frame, but owing to the steel shortage load bearing brick walls were substituted in most parts of the building. The steel rails carrying the carcases are carried by the reinforced concrete roof slab (except near the cattle shooting box, where they are carried on rolled steel joists) ; this in itself gave a saving over previous practice as it has been usual to carry these rails on a separate steel structure. The load on the cattle rails was taken as 600 lb per foot run.

Generally, normal building methods and materials have been employed ; the technique is to some extent experimental, but only in so far as internal finishing materials are concerned. The floors of the main slaughter hall, pig slaughter hall and by-products rooms are of non-slip granolithic concrete, incorporating a hardener with acid-resisting qualities, finished with carborundum and surfaced with a coarse non-slip texture. The floors of the precooling room, cold rooms and loading bank are finished with a special mastic asphalt surfaced with coarse carborundum. This gives the required flexibility, while maintaining the necessary hardness against the softening effects of fat, and at the same time provides a non-slip surface. The walls and ceilings of the whole operational area have been finished throughout with chlorinated rubber paint. These treatments depart from previous practice in which white tiles have been used extensively, and follow the general aim of the design, of obtaining the maximum economy without sacrifice of efficiency.

The lairage floors are finished in granolithic concrete, incorporating dry granite chippings in the surface to provide a coarse non-slip surface.

Splitting the Carcase

On the engineering side, normal industrial equipment has been generally used throughout. The scheme includes an experimental deep freeze room, the cost of this portion of the building amounting to £2500. The total cost of the building was £198,000, of which about £45,000 was accounted for by mechanical and refrigeration plant. The cube cost of the building and engineering, excluding services outside the curtilage, amounted to 4s. 10½d. per cubic foot.

It was designed by the Chief Architect's Division of the Ministry of Works, in collaboration with the Ministry of Food ; the main building contractor was Gee Walker and Slater, Ltd.

The Institution of Mechanical Engineers

AT a general meeting of the Institution of Mechanical Engineers on Friday, December 5th last, two papers were presented. The first of these papers, "An Experimental Investigation into the Redrawing of Cylindrical Shells," was by Dr. S. Y. Chung and Professor H. W. Swift ; and the second, on "An Experimental Investigation of the Yielding of Strip Between Smooth Dies," was by Mr. A. B. Watts and Professor H. Ford.

The first paper gave an account of an experimental investigation into the forces, work and strains involved in the first redrawing process of cups having a height/diameter ratio greater than unity, which cannot as a rule be produced from flat, circular blanks in a single stage. The work was based on a first-stage cup diameter of 4in and in the investigations the materials used included brass, mild steel and aluminium. The conditions examined included the direct and reverse methods of redrawing, first-stage drawing ratio, inter-stage heat-treatment, punch profile radius, first-stage punch die clearance, redrawing ratio, blank thickness, material and temper.

The authors considered that the results of their investigations were sufficiently accurate and detailed to give a reasonably complete insight into the redrawing process, and conclusions were drawn to assist press tool makers in the design of drawing tools. It was found that the significant difference between the direct and reverse methods of redrawing lay in the number of bending operations and in the degree of severity in bending. When this severity was the same for both methods the reverse method definitely gave better results, since it could eliminate two bending operations. On the other hand, unlike the reverse method, the direct method could, within limits, be designed to provide a larger die profile radius, and under favourable conditions might yield a better drawing capacity than the reverse method.

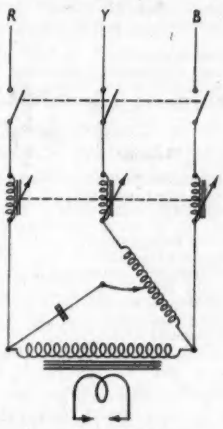
In order to obtain the maximum combined drawing capacity over two stages, the maximum first-stage blank size should be used, although the redrawing capacity itself was greater with smaller initial blank diameters. The use of inter-stage annealing was stated to improve greatly redrawing capacity, but, from a given blank, tended to produce a redrawn cup of smaller depth because its walls and base were generally thicker. First-stage cups pressed with smaller radial clearances of up to about 10 per cent gave slightly lower punch loads and higher redrawing capacity.

A Three-Phase Balancer for Welding Loads

To remedy the out-of-balance loading conditions imposed on supply mains by resistance welding machines and similar single-phase loads, Standard Resistance Welders, Ltd., Mucklow Hill, Halesowen, Birmingham, has developed a static balancer unit. This balancer is designed to reduce the loading assymmetry to such an extent that single-phase equipment, when connected to a three-phase supply, will take an effectively balanced load from all three phases.

As shown in the simplified circuit diagram reproduced herewith, the balancer consists of an inductor-reactor and a capacitor connected in delta with the single-phase primary, the junction points being connected respectively to the ganged adjustable chokes and capacitors. The inductor-reactor is tapped at suitable points to facilitate load balancing on a particular welding machine or furnace, and once balance has been thus established no alteration to the taps is necessary. The capacitance of the condenser is similarly adjusted to suit existing conditions. The accompanying diagram shows the method of connecting the unit to a single-phase resistance welder transformer.

Because the equipment is static and requires no internal adjustment, it can be housed in a completely enclosed case, preferably made of material



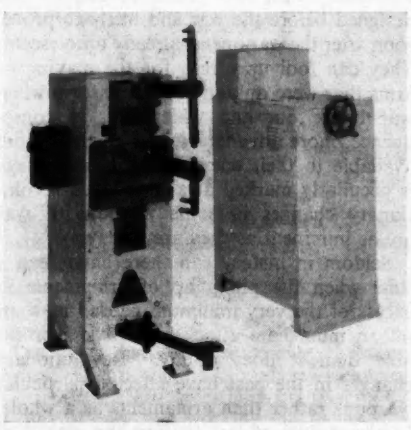
Three-Phase Load Balancer Circuit

not appreciably affected by magnetic or inductive fields. As an indication of the size of the casing it can be stated that during initial tests on a 25kVA spot welder it was found possible to mount the necessary balancer equipment in a case occupying the same amount of floor space as the welder and standing a little higher. A typical example is shown in one of our illustrations. The balancer can be remote from the apparatus it controls without in any way affecting its efficiency.

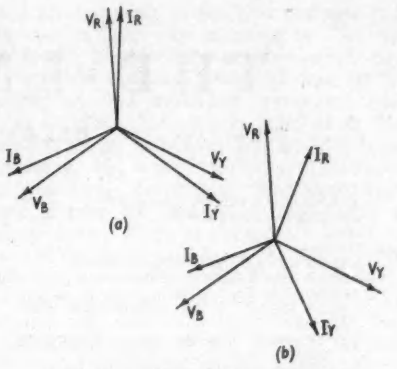
For convenience of assembly a condenser is selected having a capacitance quite close to that required, the balance being made up of small capacitors used as trimming units. As previously mentioned, the inductor-reactor is tapped at suitable points and it is also made up of small units which more completely occupy the available space than would be the case if a large single coil was used.

In addition to the above equipment, it is necessary to provide a means of switching all three phases simultaneously and an orthodox triple-pole contactor is interposed for this purpose between the incoming mains and the ganged chokes. It is by adjustments to these chokes that load variations are compensated without upsetting the fundamental balance of the unit as a whole.

In use, the position of the iron cores in all three choke coils can be simultaneously adjusted



Three-Phase Balancer for Welding Loads



(a) Near Symmetry (b) Maximum Reactance

Load Balancer Vector Diagrams

to match a given load by rotating a hand-wheel on the front of the balancer cabinet, the position required being indicated by a pointer and a scale so graduated that its numbers correspond (in the case of a spot welding load) to the gauge of metal to be welded.

Besides effectively balancing the load, the unit reduces phase current to $\sqrt{3}$ of line current, improves overall p.f. to 0·9 lagging, and provides a means of smooth, uniform current regulation over the full range of the apparatus to which it is applied.

Typical vector diagrams are reproduced herewith to indicate the characteristics of the balancer. The diagram (*a*) illustrates the most favourable conditions, the three line currents approaching symmetrical conditions. When the line chokes are set for maximum reactance the conditions are as depicted roughly in diagram (*b*). Here the symmetrical nature of the current vectors becomes upset probably because the negative-sequence component is amplified by the change in the overall inductance/capacitance ratio.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

FLEXIBLE METALLIC TUBING

No. 669 : 1952. The full title of this standard is "Flexible Metallic Tubing and Connector Ends for Appliances Burning Town Gas."

Subsequent to the publication of the first edition of the British Standard in 1936, demands for an additional type of covered tubing for use with portable appliances and for a new tubing for heavy domestic and industrial uses became evident ; these have been met in the revised specification. The specification has, therefore, been divided into two parts ; the first dealing with general purpose domestic tubing and connector ends for portable appliances, which includes both plain tubing and tubing with a plastics or synthetic rubber cover ; part 2 of the specification gives the requirements for materials and dimensions for heavy duty armoured tubing and connector ends. The covered tubing for general domestic use differs only from the plain tubing in that it is provided with a plastics or synthetic rubber cover ; it is intended for use as an intermediate pattern between the plain domestic tubing and the heavy-duty armoured tubing. The heavy-duty tubing covers a wider range of sizes and includes, in addition to the normal male and female connector ends, a union end to facilitate fixing. The test requirements, which are more severe than those for the general-purpose tubing, include a bend test, gas resistance test and detailed tests for the quality of the plastics cover. The specification has ben prepared primarily from the standpoint of ensuring the availability of an easily distinguishable, sound and satisfactory tubing. Metal screwed connector ends have been adopted to ensure maximum safety in use. Certain clauses covering the quality of rubber used in the construction and assembly of the tubing have been modified, clauses covering tensile strength extended, and new clauses included covering crushing strength and the quality of nickel plating used on springs. Certain finishes have been deleted, and additions and modifications have been made to the dimensions of the tubing in the light of current manufacturing practice. The specification does not provide for tubing which is required to be electrically-insulated from end to end ; in such cases, special insulating washers are necessary on the inside of the metal connector ends and the covering material must possess adequate insulating properties. Price 6s.

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SLOWING DOWN DEFENCE PRODUCTION

The changes in the defence production programme announced by Mr. Churchill in the House of Commons last week do not mean, save in certain particular fields, that there will be any reduction upon the present rate of output of arms. But, whereas the previously existing programme called for a quite substantial increase in expenditure upon equipment next year, the new one is designed to hold the arms production rate steady at about its present figure. Though in the end about as much new equipment as was envisaged will be made available to the armed forces it will take longer to make it. The object of thus allowing the provision of arms to fall well behind the original schedule is, of course, to help the economic recovery of this country by permitting the engineering industry, in particular, to devote more of its expanding productive resources to the manufacture of goods for export. Release from the obligation to carry out defence contracts may permit those firms to quote more attractive delivery dates in export markets. It also appears from Mr. Churchill's statement that the opportunity will be taken to tail off more rapidly than had been planned, deliveries of equipments which, if not already obsolescent, can soon be expected to become so. But, presumably in the interests of maintaining a balanced programme as a whole, the production of certain products by no means yet nearing obsolescence is also being subjected to some reduction, either absolute, or relative to the pre-existing programme.

Under the existing economic situation some such decision can hardly be regarded as surprising. It is, after all, better to accept a shortfall in rates of defence production than to risk bankruptcy in the attempt to maintain the schedule! But, in fact, because the immediate danger of an outbreak of war has receded since the time when the Socialist Government set rearmament in motion, the present decision to slow it down can be welcomed upon quite other grounds than those of economics alone. It is only short wars that can be won by a preponderance of existing military material over that of an enemy. The quantities of armaments available to the belligerents at the opening of a long war have little bearing upon its later character. For long wars are won by those countries which can most effectively and most rapidly convert existing peace-time productive capacity to arms production and, as importantly, have at the outbreak of the war prototypes of new equipment sufficiently far advanced to be put rapidly into mass production. Thereby, once the first battles are over, they can build up a preponderance not only materially but in quality of material as well. But as the democracies of the West are never likely to be aggressors so, too, they are never likely to be able to build up so large a preponderance of military strength over prospective enemies as to make short wars possible. They must be prepared to fight long wars. To do so they need only sufficient forces, in being and equipped, to absorb, defensively, the first "crunch" of the war and to give protection whilst productive capacity is built up. Thereafter they are likely to gain the advantage. For they are not committed, as is the aggressor, to the mass production of weapons designed before the war and likely to prove, soon after the war opens, already obsolescent. They can tool up afresh for the making of arms that were only in prototype form when war broke out and which are, in consequence, more advanced in design than those available to their enemies. That advantage is peculiarly marked at a time when revolutionary changes in some weapons of war are as imminent as they are to-day.

Seldom in history can there have been a time when the piling up of armaments in excess of the very minimum needed to ward off an immediate attack seemed less profitable than it does to-day. Revolutionary changes in the past have affected particular weapons rather than armaments as a whole. In the middle of last century the advent of the "needle gun" made it a waste of time and labour to multiply muzzle-loaders; very early in the present century the launching of the "Dreadnought" outmoded every battleship of earlier designs; in 1914 experience against machine-guns indicated the wastefulness of labouring to manufacture an abundance of cavalry equipment. Each of those new weapons rendered nearly useless particular arms that had been manufactured in quantity before. But to-day, prospectively, almost every type of weapon and much other equipment besides lies under threat of sudden obsolescence. It is not merely that rapid technical advances are being made in the design of aircraft and, we hope, in ships and tanks and guns, and much other material. For equipments of those kinds are likely to have at least several years of useful life before obsolescence really sets in. The disturbing revolutionary factors are the secret developments in "rocketry" and atomic weapons whose effects upon the design of other military equipment cannot be accurately assessed, though they are obviously likely to be profound. No one is yet certain to what extent rocket weapons and guided weapons will be able to supersede conventional guns and bombs. Yet, until the doubt is settled it seems profitless, for example, to start building any battleship similar to those used in the last war. Nor can any army feel confident in its powers if equipped only with guns and tanks similar to those used only seven years ago. For what kinds of weapons are going to be used against them? How effective will their equipment prove against rocket-guns, guided missiles and tactical atomic weapons? Armaments this country must have. For in the interim, whilst such new weapons are being developed, we must be able, if attacked, to defend ourselves. Yet it is well to remember that within a very short term of years much of the equipment now being manufactured may be of little more use than an "ironclad" in the presence of the "Dreadnought." It is, in fact, less important now to expend vast sums of money and absorb much productive capacity upon present equipment than to press urgently onward the development of new equipment better suited to a war of rockets and atomic weapons; and to have ready, continuously at all times, plans for the rapid production at need of the latest designs available if war becomes imminent. Wisdom, too, suggests that in peace the problems of production of particular types of arms should be studied continuously so that if war-time mass production becomes essential few production difficulties will have to be solved hurriedly and perhaps expensively on the factory floor instead of quietly and without haste beforehand.

THINKING TO SOME PURPOSE

So much has been spoken and written about research in the years since the war that it might be supposed that really very little more could be worth saying. Yet those who turn to page 807 of this issue will find that, in a paper read before the Automobile Division of the Institution of Mechanical Engineers last Tuesday, Dr. Merritt said much that is now very well worth reading. Nor should it be supposed, just because the paper was presented before that particular body, that it

had relevance only to automobile engineering. In that major part of the paper which we reprint we doubt whether the word "automobile" once appears; and the relevance of the discussion to vehicle design is revealed only in the last of the paragraphs we print. For Dr. Merritt spoke about research in general and in particular about its relationship to the engineering process, the business of designing, making and using engineering machines. Many who pride themselves upon being practical engineers fail to understand research men and consequently undervalue the work they do. Their reliance is placed in their practical and "intuitive" knowledge of what can be done with engineering mechanisms and engineering materials. Yet, as Dr. Merritt remarked, "It is easy to forget that the engineer's stock-in-trade of design calculations, from arithmetic upwards, represents the accumulated research of centuries." In fact, without research in the past—it did not then bear that exalted title and no doubt was not as accurate and scientific as it is now—there could be no safe and reliable "rules of thumb" to-day!

We do not want to give the impression that Dr. Merritt set out to exalt the research worker above all other engineers. He did no such thing. He showed no undervaluation of "mechanical aptitude, which consists largely of the power of visualising the way in which mechanisms will behave, coupled with an intuitive sense of the character of materials." But he stressed that "the scientific method first requires that its practitioner should be a genuine seeker after truth" and that "this approach, not easily acquired even in the laboratory, is more difficult to adopt in the hurly-burly of industrial life, and requires the discipline of training." He stressed, too, that "unless the scientific method or the research attitude is understood beyond the ranks of research workers themselves the initiation or application of research by engineers will inevitably be retarded." He wanted the scientific method to be employed, not only in the laboratory and the works, but outside the works as well. It is, for instance, often suggested that ideas for improvements in, or the origination of, machines should come from customers. In fact, they must at least as often start amongst makers. Hard critical constructive thinking by the latter in the light of knowledge of engineering capacities and limitations may lead to "an idea not of what the customer wants, but of what he would like if he saw it." Nowhere probably is hard scientific thinking more needed than when troubles are met. For "it is one thing to have trouble and quite another to define the problem that underlies it." Not very many years ago oil engine builders were troubled by a series of mysterious fractures of crankshafts. It was easy to see that some factor was being overlooked in design, but far too simple to suggest merely that the shafts were not strong enough, to blame misalignment or suggest the presence of stress-raisers. No advance could be made until out of hard thinking and scientific investigation it was perceived that the problem lay in the avoidance of torsional oscillation. That was a problem amenable to solution. Research is so valuable a weapon when properly directed, and can bring such very large returns for the money expended upon it that it is difficult to believe enough resources are yet devoted to it. It is true that, if research receives too little support, the fault does not lie wholly with industry itself. For very often research workers publish their results in such a form that designers and workers within industry cannot immediately appreciate their valuable applications. Moreover, many of those who advocate more extensive research forget how much applied research and development is done within industry itself. Yet even so, the ratio between expenditure upon the work of the Motor Industry Research Association, for example, and its industry's turnover, at a mere 0·02 per cent—a figure no lower than could be quoted for several other industries—seems surprisingly inadequate. Is that rich industry unwilling to expend more than about £100,000 a year upon work that could over the years immensely increase its power to compete against all comers in the markets of the world?

Curiously enough, the gradual intensification of research that has taken place within this century has bred a new problem that will demand hard thinking as much as any engineering problem. How many minor researches, we wonder, are put in hand, how many avoidable mistakes are made in design or manufacture just because the engineers concerned either did not know where to look for information, did not realise that it might be worth looking for, or found it less trouble to try to get along without it? Though little enough even to-day is being spent upon research, the outpouring of technical papers and research reports has already become so large and is growing so torrentially that the use of research is in danger of being choked by the difficulty of sorting out particular information required from this mass of technical material. Nor is that all. If research is to be applied widely it must be applied by engineers more directly concerned with design, manufacture and use than are research workers. But, as Dr. Merritt remarked, "the real problem for the busy engineer is to find time to study all his problems with the care and thoroughness that they deserve—even the time to reflect upon the kind of information that might be available and the place from which it might be obtained." But, perhaps, after all that is an old problem. In all history relatively few men have been granted the blessing of leisure to think and even fewer, granted the blessing, have been capable of deriving much advantage from it.

Literature

The Nile. By H. E. HURST, C.M.G., M.A., D.Sc., F.Inst.P. London: Constable and Co., Ltd., 10-12, Orange Street, W.C.2. Price 30s.

THE author of this work has spent a busy life in studying the regimen of the Nile and was responsible for initiating several engineering schemes for its control, and has painted in this book a vivid picture of the great river's present problems and future destinies.

The text is divided into seventeen chapters, beginning with three introductory chapters of general interest, describing the geography of Egypt and the working of its world-famous irrigation system. Sketches are used to aid the understanding of the structural arrangements of the Nile barrages and the Aswan dam. In referring to the two successive heightenings of the latter, the author goes possibly somewhat too far in postulating that transverse cracks are *ipso facto* harmless, for even in solid dams the question is by no means finally settled, as evidenced by some advanced American specifications, prescribing the trial load method even for straight dams—should a certain height limit be exceeded. But if a dam is provided with large, closely spaced openings, as is the case with the Aswan dam, cracks, in whatever direction they chance to develop, may eventually play havoc with the structural stability of the work. On the other hand, fond as the author seems to be of physical measurements, it is a little surprising that he does not mention the recorded observations of the thermal deformations of the buttresses of the second heightening of the dam,* the almost clockwork precision and consistency of which testify to the high class and accuracy of the work carried out in bringing into life this remarkable structure.

In describing basin irrigation as practised in Upper Egypt, the author speaks about short canals only and omits to mention Colonel Ross's splendid remodelling works, based on the principle of filling the basins through long canals, running at flatter slopes than those of the river. This system was widely used in the 'nineties and resulted in materially reducing the "sharaki" areas left dry in the low floods. It is commonly considered to be one of the most creditable works accomplished by the British engineer in Egypt.

A diagram on page 55 of the book, purporting to portray the perennial system, might have been improved had the main feeders depending on the different barrages been shown to overlap—a characteristic point of the modern Upper Egyptian canal system. For "Father Nile" does not only feed this system with the "life-giving" water it needs, but acts also during the season of low water levels as a powerful drain. In order not to deprive cultivation of this beneficial action, the modern concept of an irrigation head work is a combination of barrage-cum-canal, the latter being designed on Colonel Ross's principle. Thus, the area depending on the barrage starts only at some distance downstream from the spot where it is built—about 40 miles under conditions prevailing in Upper Egypt—which explains the necessity for the overlap.

These minor criticisms relate, however, to rather more technical points, and since the volume is obviously not intended for an expert designer, they are *peu de chose* as compared with the wealth of the manifold information presented in the following chapters of the book, devoted specifically to the Upper Nile and its tributaries, beyond the geographical boundary of Egypt. Although some of this information had previously appeared in the author's departmental publication,† the bulk of it is new to the general public. This fact enhances the value of this lively narrative, in which a mass of geographical and historical data are interspersed with personal experience collected during numerous journeys to the heart of Africa, frequently carried out under adverse natural conditions and by rather unorthodox travelling methods.

Climate, vegetation, hydrology, and various other items of information bearing on the major Nile projects constitute the subject matter of the last seven chapters of the book. Here again the author is at his best, for he spent many years acting in the capacity of

* *Journal I.C.E.*, March, 1948, page 79.

† *The Nile Basin.* Cairo Government Press.

adviser to the Egyptian Government on all matters concerning Nile control. His mathematical solution of "Joseph's Problem" (page 299), i.e. storing water in fat (i.e. high) years to be used in lean (i.e. low) years, has recently been presented to, discussed and highly praised by an authoritative American society.‡ The role played by scientific measurement in the study of the regimen of the Nile, and of the means for improving it, to the advantage of the population inhabiting its basin, is the leitmotif of this part of the volume. The story of how statistical study of the annual growth rings of giant American trees has finally led to the concept of the Lake Victoria reservoir, now in the course of construction, in Central Africa, is as fascinatingly told and is as fascinating to read as a detective thriller.

The book is an easily read, but expert, statement of the various problems centring on the Nile, with their various interpretations and just enough geographical and historical background to facilitate grasping their essence. It will be appreciated by all who seek deeper information on the up-to-date topics frequently reappearing in daily periodicals.

The Mechanics of Vibration. By H. M. HANSEN and P. F. CHENEA. London: Chapman and Hall, 37, Essex Street, W.C.2. Price 64s.

So many textbooks on vibrations have appeared in the last few years that it may well be asked what purpose is served by yet another. In the present case, however, it can be confidently stated that the authors, who are both at the University of Michigan, have brought something new to the mounting pile of books on the subject, and show an insight and appreciation of the fundamentals which recommend their book to the engineer.

The study of vibrations is not an easy one for the average engineering student, who may not find mathematical concepts easy. Hansen and Chenea have dealt with these concepts in a very thorough manner and have left unexplained nothing which might puzzle those who may be encountering the subject for the first time. Several methods of presenting the fundamentals are given and this is a very good feature of the book.

The authors have divided the work into an introductory section and three main parts. In the introduction the general concepts and characteristics of vibratory systems are described and related to the kinematics of simple harmonic motion. In Part I systems with one degree of freedom are dealt with; free and forced vibrations with and without damping. While the topics covered are necessarily to be found in every textbook, the treatment in the present case is remarkably clear and thorough, with a good selection of examples and applications. In Part II systems with several degrees of freedom are treated, and the use of Lagrange's equations described with examples. The treatment of the mobility method and Holzer's and Graeffe's methods for the solution of the general frequency equation is very satisfactory. In the third part the authors have collected together a number of special topics: in future editions they might well extend this section to include more advanced applications.

Instead of placing at the end of each chapter a selection of problems for solution, the authors have assembled some 330 problems in varying stages of difficulty at the end of their book. Many of these are new and show a remarkable resourcefulness and wide experience of practical applications.

‡ Hurst: "Long-Term Storage Capacity of Reservoirs," *Transactions of the American Society of Civil Engineers, 1951.*

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

A GAS TURBINE LOCOMOTIVE EXPERIENCE

SIR,—The concluding paragraph of Mr. Hill's letter in THE ENGINEER of October 31st makes it advisable for me to underline and amplify one or two points in the account of the gas turbine engine's running between London and Bristol, though I do so somewhat reluctantly, as I had hoped the article itself was sufficiently clear and made my attitude towards non-essentials plain enough. These include data concerning both engines and trains of a kind which are only of interest to a very small number of THE ENGINEER's readers, and which, I personally think, have been overdone.

Mr. Hill would have liked "fuller details of the position of the master controller at various points on the run." I am afraid I do not see that this would have been of much value or add to the interest of the account, because they would tell nothing of importance, the speed, load, gradients and engine power being what they were. In the early stage of the run I did take a few notes of this kind, but ceased to do so on realising their triviality, and for the same reason left them out of the script. The runs were mediocre, as so much of the present-day British locomotive work unfortunately is; mediocre, I hasten to add, not because of any shortcomings inherent in No. 18,100, which did all that was asked of it and a little more. The loads, speeds and schedule were such that the engine was playing with its job throughout, and, this being so, there was no need to go into everything with a fine-tooth comb.

It was set out in the article that the maximum effort exerted by the engine noted at any time corresponded to 80/110ths of the controller quadrant, 110 representing a tractive effort of 60,000 lb at or below 14 m.p.h., and it was also stated that "no effort was made to extend the engine, which was working well within its power (maximum understood) throughout, even up the Box and Dauntsey inclines, . . . the two runs were in no way a real test of the engine's capabilities." This being the case, I do not see how detailing controller figures was necessary; they would come under the heading of superfluities, "padding," trivialities that so often are found in accounts of footplate work.

It was also pointed out that the controller was equivalent to a combination of regulator and reverse lever, the major controls on a steam locomotive, the movement of its handle having much the same effect, which brings up the matter of how it is "worked." Some readers may not understand or grasp that No. 18,100 is essentially an *electric* locomotive, and is therefore "worked" as such, on the controller, like any other electric locomotive of basic design, and not primarily on the turbine. Functionally, No. 18,100 only differs from the former—or from a tram, for that matter—in that they obtain their power from an outside source, whereas the gas turbine engine carries its generating plant on its chassis. This also applies, of course, to a diesel-electric locomotive. All are "worked" in the same simple way, on the controller. I would suggest that anyone who is not clear about this should take a trip in the driver's compartment of a tram and watch closely how the controller is handled, noting just what happens to the tram as the handle traverses the quadrant, its wonders to perform. He should pay particular attention to (1) the ratio of notches to speed; (2) ditto to acceleration per second; (3) condition of rails, whether wet or dry, under a bridge or out in the open; (4) gradients up or down or non-existent; (5) &c. &c.; (6) time since the driver left the "Spotted Dog"; and (7) how long he was inside! All these things have a direct bearing on how a controller is "worked," and at the end of the trip the observer will be in possession of a mass of figures which, after being reduced to sea level and corrected to Fahrenheit, will be of the greatest interest—to him, but probably to nobody else, and certainly not to readers of THE ENGINEER. One worthwhile thing would emerge from his trip: he would understand beyond a peradventure how a gas turbine-electric locomotive is "worked"—just like a tram. Boiled down, it comes to this: if the driver of No. 18,100 handles the controller with confidence—with a certain amount of *abandon*, as it were—the engine will accelerate with corresponding vivacity and climb gradients with considerable rapidity; if he does not, it would not. Simple, is it not? And so elementary that I did not consider it necessary to labour the point in the article.

The runs made with the gas turbine engine described in the article bring out two features: (1) the mediocrity of the performance; and (2) the valuation placed by the writer on what is worth stressing and what is not; that is to say the *differing* valuation an overseas visitor places on what is worth detailing in locomotive performance, as against that of the "timing and measuring school," to whom apparently anything and everything is worth noting. As I saw it, No. 18,100 did nothing whatever out of the way in either direction between London and Bristol, except on the two inclines, Box and Dauntsey, and even there it was not given its head. The whole performance was mediocre, but here I would underline again that *this was not because of the engine's limitations*—the load and schedule together made it impossible for it to show its capabilities. Instance the "high-light," as some would regard it—the Swindon/Reading section—I draw particular attention to this. For the life of me I cannot see anything to enthuse over in an engine with a maximum tractive effort of 60,000 lb hauling a 445-ton load at an average speed of 74·5 m.p.h. over a distance of 40 miles, every yard of which is either level or downhill, mostly the latter, upon which it had entered with a flying start of 70 m.p.h. What is there in that? I have no doubt whatever that such a performance has been equalled and exceeded on thousands of occasions all over Britain during the last fifty years. It seems to me just ordinary, everyday locomotive work, not deserving of any special attention or analysis. The sort of locomotive work this overseas visitor regards as worth description is that of C.N.R. No. 6200, an engine with a tractive effort of 45,000 lb, hauling the 1200-ton "Inter-City Limited" over a heavy route through terrible weather, and covering most of it at 80 m.p.h. *That* is worth some enthusiasm—the other is not. Again I say, this is casting no reflection on No. 18,100, which was fully capable of much heavier work, and no doubt would have tackled it successfully. I detail the foregoing to stress the sort of values I brought to Britain, and which I have seen no reason to discard. During an unforgettable visit to my native land—where approximately 75 per cent of my heart still is, so I cannot be accused of lack of sympathy or an over-critical attitude—I travelled many thousands of miles in cab and train, always looking for the good, and only too willing to overlook the—well, let me say, less good, but I am obliged to admit that I saw very little locomotive work meriting enthusiasm, still less writing about. Good engines, yes—exceptional work, very little; mostly mediocre. Curiously enough, my enthusiasm was roused almost for the first time on the last trip from London before sailing. From St. Pancras to Sheffield, one Sunday, the train really did do a sparkling performance, and I was actually so roused that I even timed many miles, a thing that as a rule nothing will induce me to do, clear proof we really were travelling. At Sheffield, full of good will, and further impressed and surprised by arriving three minutes early, I went to the front to congratulate the driver—only to discover

there were two engines on the train. At this anti-climax I turned sorrowfully away, my compliments uncalled for, my enthusiasm doused. And so, unfortunately, it was on most occasions recently I *wanted* to see the good and outstanding, but was seldom given the opportunity. For this state of things, however, I am absolutely convinced that neither British Railways nor the Executive is to blame, the cause being fundamentally another story.

The old saw that a looker-on sees most of the game can, of course, be taken too far, but it does apply to a visitor from overseas who spends fifteen months in Britain and France with his eyes well open and his interest keenly roused, and who travels many thousands of miles on all sorts and conditions of locomotives and trains in both countries. What he saw may be of some interest to others who do not have this opportunity, but let it be borne in mind that when he sets down his impressions, such a writer does not always aim at satisfying one class of readers only ; he may spread his net wider, by which I mean my poor efforts are not intended for railway people alone, but for other classes not directly concerned with locomotives ; for people who I am convinced, would be bored stiff with minutiæ, but who are far more likely to prefer a general picture, an outline, rather than a sectional drawing. For this reason, if for no other, I am warranted in not bothering about endless analysis and am justified in introducing matter which is not, strictly speaking, directly concerned with the main subject. It is done by way of "for this relief, much thanks" ; that is how I feel and, I believe, so do many readers.

A visitor, further, may have a fresh point of view and very likely a different set of values—as I have. In nothing is this more the case than in my attitude to this overdone, in my opinion, cult of exaggerated concern in the performance of any and every locomotive, interesting or otherwise, ancient and modern, active, moribund or dead ; good, bad or indifferent, about which nothing fresh can be said ; in trains we know all about, running over routes most people are well acquainted with, which unfortunately at present are not even measuring up to pre-war standards. It is a cult that flourishes in no other country, so far as I am aware, and though doubtless harmless enough, has been overdone. It is all much ado about nothing. It seems to me a parallel to "spotting," and to be just about as useful—platforms cluttered with yelling, booing "spotters," wildly waving notebooks and caps, a nuisance to station staffs and a danger to themselves and legitimate travellers, and in imminent peril of falling on to the track and being cut to pieces—similar misguided wights decorating lineside fences and festooned on bridges, all wasting their time at this puerile tomfoolery. It really makes one wonder what has happened to the youth of the nation. One never saw this sort of thing in my young day ! If readers could hear what railwaymen think of it, and have not scrupled to voice to me in forthright terms—of signal wires interfered with, of points packed with gravel, and so on—they might come to the same conclusion, that if is another initially harmless amusement spoilt by being overdone and getting out of hand. I do not wonder that "spotters" have been barred from many stations—Sheffield is one and Preston, I believe, another—and that on occasion the most objectionable type is brought into court and fined. This "spotting" crotchet is one of the most clearly etched British railway pictures that has been taken back with me to Canada, though caricature might be a better description. But enough of this ; the subject was merely mentioned because, frankly, "spotters" and "timers" have something in common—both might be more usefully employed. To sum up, excessive preoccupation with locomotive minutiæ does not interest me ; nor, I opine, the majority of my readers. If it did, I might have emulated one enthusiast who, travelling on the footplate, and apparently at a loss for something to write about, carefully recorded the number of shovelfuls of coal fired per minute—or per mile, or what have you—but omitted to state the quantity the shovel contained, thus leaving his readers in the air, as wise as before. His account was published in a technical journal, too ; but I will be merciful—it shall remain anonymous, and the author also. Have I made myself clear ?

EDWARD H. LIVESAY

Victoria, B.C., Canada, November 27th.

ENGINEERS GUILD

SIR,—I do not feel that the Engineers Guild will achieve their object by pursuing their present policy with regard to membership.

There are many members of the profession who are at present holding senior positions requiring administrative ability who do not enjoy corporate membership of the so-called "major" Institutions. There are also many corporate members of these Institutions who will never be capable of taking their place in management. Whilst it is obvious that some technical training and background is essential, the ability to "manage" comes from an inborn combination of character and personality, together with the capacity to organise the efforts of others to the best advantage.

Do the Guild think they are wise to ignore the potential that is available to them outside corporate membership of the Institutions of Civil, Mechanical and Electrical Engineers ?

K. H. ENGLAND

Swansea, December 5th.

SIMPLICITY IN GEARS

SIR,—There are two points in Professor M'Ewen's letter (page 764) that need comment.

The present general proposal is that British Standard gears shall be producible by British Standard cutters and not that there shall be British Standard dimensions for gears. On the contrary, the proposals show the designer that he has considerable latitude even when using extremely simple design procedure that never demands a non-standard cutting tool. If two manufacturers are required to produce interchangeable gears (or anything else) the first essential is that they use identical drawings. In practice this means prints off the same drawing and not merely instructions to use a formula. I have never suggested that there is, or should be, any identity between dimensions of screw threads and worm threads. My point was that screws, worms and helical gears are identical in the possibility of production by sinking a standard cutter to full depth in a blank while the two have appropriate relative motion and consequently that presentation of manufacturing dimensions need be no more complicated for one than for another.

W. A. TUPLIN

Professor of Applied Mechanics.

Sheffield University, December 8th.

Fifty c/s Electrification of Lancaster, Morecambe and Heysham Line

THE railway line between Lancaster, Morecambe and Heysham has recently been re-electrified, using the 50 c/s alternating current system of electric traction, and trial running for experimental purposes has begun. It is not expected, however, that service running will come into operation until the New Year.

This line was first electrified in 1908, as an experiment to test the use for electric traction in this country of alternating current at 25 c/s, supplied to an overhead contact wire. Recent technical developments have opened the possibility of designing satisfactory train equipment for operation from the standard frequency supply of 50 c/s. As compared with direct-current traction systems, alternating-current systems have the advantage that a higher contact wire voltage may be used, so that the substations feeding the overhead wire may be much further apart, and at 50 c/s the substation equipment becomes very simple.

The original trains of the Lancaster-Morecambe-Heysham line had to be withdrawn from service in February, 1951, due to age. The overhead equipment, however, was in good condition and suitable for use at a higher frequency. British Railways therefore decided to convert the line for 50 c/s operation at the original voltage of 6·6kV. A new substation fed from the North Western Electricity Board's network has been built at Green Ayre Station, Lancaster, to supply electricity to the line, and replaces the old motor generator substation at Heysham. Three existing three-coach electric train units have been refitted and rectifiers feeding d.c. motors installed in them. Nearly a mile of the original overhead equipment has been taken down and a variety of modern types of equipment installed in its place for trial.

Springs

ON Friday, November 28th, W. E. Frost, M.Eng., read a paper, entitled "Springs," before the North-East Coast Institution of Engineers and Shipbuilders.

This paper describes the manufacture of springs and gives a general survey of the industry in this country. Typical applications of tension and compression springs are noted and it is stated that for heavy springs the main application is the suspension or bearing spring which may be a torsion bar, volute, coil or laminated spring, or a combination of these varieties. All springs are subjected to combined stresses, but each pattern has a principal stress such as torsion for helical and torsion bars, shear for volute springs and bending for laminated springs.

Eight principles in steel spring production are enumerated and emphasise the need to avoid stress raisers, the necessity of a corrosion-free surface, the need to restrict the stress range when associated with a high mean stress, and note certain factors which affect fatigue life. The importance of the principles are underlined by the statement that the usual mean stress for a bearing spring is 25 tons per square inch, plus or minus 10 for railway springs and 35 tons per square inch, plus or minus 16 for a car rear spring. The practical way to satisfy the principles are reviewed and a Brinell hardness number of 320/350 for laminated and 425/475 for helical springs is quoted, while a table gives the preferred analysis.

The next section of the paper sets out the main manufacturing details of laminated springs, and also hot and cold coiled helical springs, together with illustrations. Design formulæ, given in an appendix, are discussed, and the deflection formula for laminated springs is stated to be correct for a well-designed spring based on the rhombus system. The British Standard test deflection gives a skin stress of 64 tons per square inch and stresses the material beyond its elastic limit, but, it is stated, no detrimental effect on fatigue life has been revealed.

There are some notes upon the testing of coil springs, upon the methods of ordering springs, and a brief reference to spring repair and identification. In discussing the design of laminated springs a general figure of 3in deflection per ton is given for buses and 0·3in or less for locomotives, while for comfortable riding an acceleration of less than g is declared satisfactory. Design details are surveyed and since abrasion can cause a reduction in thickness of 0·02in per 50,000 miles' service, a spring life is recommended. The paper concludes with some general notes upon initial tension, special designs of helical springs and stranded wire springs.

HUMAN RELATIONS IN INDUSTRY.—The Industrial Welfare Society is arranging a five-day course for junior executives on the subject of "Human Relations in Industry." It will be held from Monday to Friday, January 19 to 23, 1953, under the direction of Mr. J. Jefferson and Mr. Gordon Bevan, at Robert Hyde House, 48, Bryanston Square, London, W.1.

Notable Locomotives of 1902

By E. C. POULTNEY, O.B.E., M.I.Loco.E.

Four locomotives that made their appearance fifty years ago are briefly described. They are the G.W. 4–6–0 engine No. 100, which was later named "William Dean," Ivatt's G.N. "Atlantic" No. 251, with wide firebox, Holden's G.E. experimental ten-coupled tank engine for intensive suburban service, and Hoy's Horwich-built freight locomotive with a cylindrical firebox.

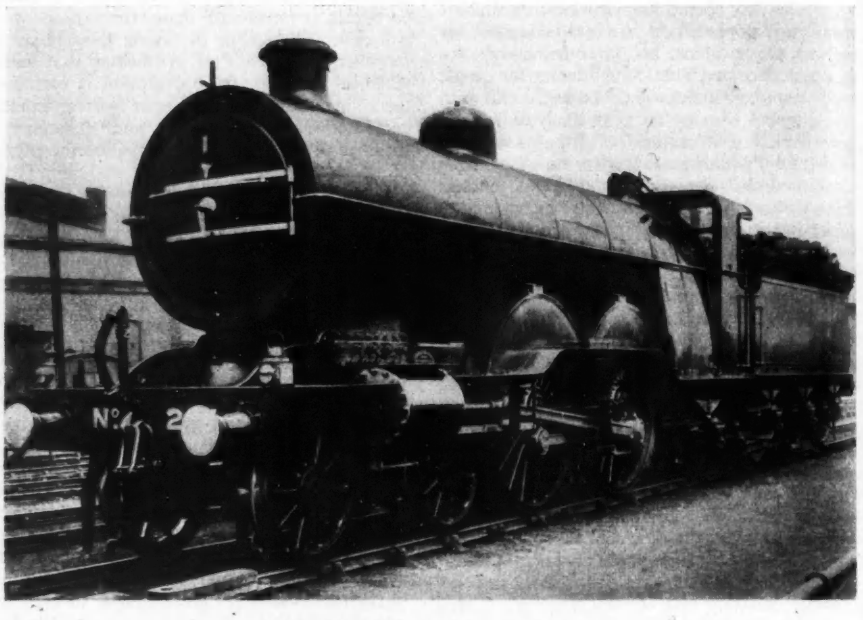
LOOKING back over the last half-century, the year 1902 stands out as marking a period when clearly defined progress was made in the development of British locomotives.

Early in that year there emerged from the Swindon works of the Great Western Railway an engine representing an entirely new design when compared with previous practice, in the form of a six-coupled locomotive for fast passenger traffic. In this year, also, H. A. Ivatt produced at Doncaster his famous enlarged "Atlantic" express locomotive No. 251, distinguished by the provision of a boiler of outstanding proportions, representing an important advance in steaming capacity compared with former British practice. Both these locomotives proved to be the patterns for subsequent developments. The Great Western engine No. 100, later named "William Dean," attracted attention to the possibilities offered by the six-coupled 4–6–0 class for passenger service and Ivatt's "Atlantic," with its large boiler, having a wide firebox, may surely be said to have been a pointer to developments of many years later when an equally famous "Pacific" design left the Doncaster shops in 1922.

The year 1902 also saw the building at the Stratford works of the Great Eastern Railway of a remarkable experimental locomotive, due to James Holden, intended for heavy local passenger traffic, while a further interesting development well worth recording was the construction of a novel form of boiler, designed by H. A. Hoy as a modification to a class of eight-coupled freight engines of the 0–8–0 type in use for freight traffic on the Lancashire and Yorkshire Railway. Turning back to the new Swindon engine, though it may probably be said that this 4–6–0 led the way to the future use of these engines for passenger services, it cannot be claimed that it was the first built for this class of traffic. As chronicled by the writer in THE ENGINEER, July 29, 1949, W. Worsdell's 4–6–0 North Eastern engines of 1899 have this distinction, though these and the succeeding series of 1900, though meeting with more or less success, ultimately gave way to much larger engines of the "Atlantic" type, also introduced by Worsdell, later in 1903.

The Great Western engine, on the other hand, firmly established the six-coupled class on that line and was quickly followed by express locomotives of the same design on other lines.

Moreover, though Churchward subsequently gave an extensive trial to an "Atlantic" version of the same general design, these were ultimately converted to the 4–6–0 wheel arrangement; thus, we see an exact reversal of the policy pursued on the North Eastern.



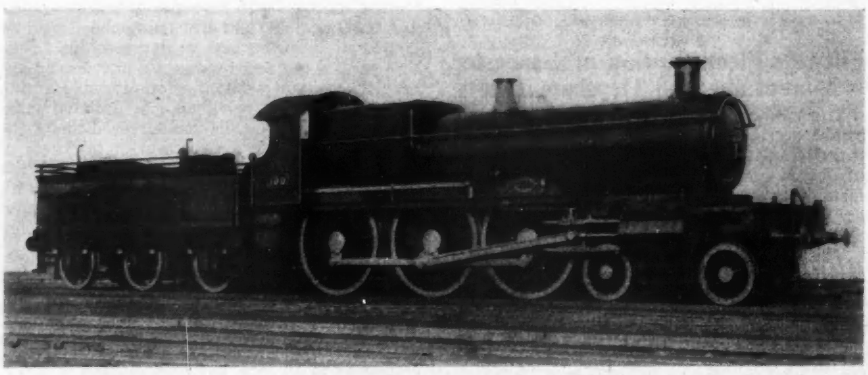
Great Northern "Atlantic" Express Locomotive

THE GREAT WESTERN LOCOMOTIVE No. 100

As originally built, No. 100 is illustrated by the accompanying photograph, from which it will be seen how greatly it differed from previous Swindon designs. At the time this engine was completed, February, 1902, W. Dean, who had held the office of locomotive superintendent of the Great Western since 1877, was about to retire and had, in fact, already largely relegated his duties to G. J. Churchward, his chief assistant, who actually succeeded him in June, 1902. There seems little doubt that Churchward was mainly, if not entirely, responsible for the design of the new engine, the fundamental features of which characterised all his two-cylinder engines subsequently built at Swindon.

In designing No. 100, many different departures were made from normal British practice by introducing features of American origin. Thus, the outside cylinders were in two castings with half saddles supporting the circular smokebox, and, to accommodate this construction, a supplementary bar frame was used for the front end. This novel frame became a distinguishing feature of all Churchward's standard two-cylinder engines and was illustrated in THE ENGINEER of May 13, 1904. The valves, of the piston type, 6½in diameter, were in valve chambers inside the frames and rather above the cylinders; they were operated by Stephenson's valve gear through rockers, which, in arrangement and detail design, followed American practice. In fact, in many respects Churchward's arrangement resembled that used for the American 2–6–0 engines imported during 1900 and referred to by the writer in THE ENGINEER of December 9, 1950.

Other outstanding features included a bar frame for the leading bogie, the introduction of solid bushed main crank pin bearings in the connecting-rods, since very generally adopted, and compensating levers for the spring suspension of the coupled axles. The illustration shows the boiler to have had a raised Belpaire firebox, giving a large steam space between the inner and outer crown plates, while the absence of a dome will also be noticed. The cylinders had a diameter of 18in and the unique stroke of 30in, compared with 24in or 26in more generally employed. P. Stirling, it may be recalled, used a 28in stroke for his famous G.N.R. 8ft "singles," designed in 1870, while a little later, in 1872, Bouch on the N.E.R. built some 4–4–0 passenger engines having 17in by 30in cylinders, the latter



Great Western Six-Coupled Express Locomotive No. 100

Dimensions of Locomotives—1902

Railway	Great Western	Great Northern	Great Eastern	Lancashire and Yorkshire
Type	4–6–0	4–4–0	0–10–0	0–8–0
Cylinders : number, diameter and stroke, in	Two, 18 by 30	Two, 18½ by 24	Three, 18½ by 24	Two, 20 by 26
Driving wheels, diameter, in	80·5	79·5	54	54
Boiler steam pressure, lb per sq in	200	175	200	180
Heating surfaces, sq ft :				
Tubes	2,252·37	2,359	2,878·3	1,775
Firebox	157·94	141	131·7	125
Total	2,410·31	2,500	3,010·0	1,900
Grate area, sq ft	27·62	30·9	42	26
Rated tractive force, lb	20,525	15,690	39,100	29,400
Weights, tons :				
On driving wheels	52·5	36·0	80	57·93
Engine, total	67·8	68·4	80	57·93
Tender	43·15	43·1	—	41·45
Total locomotive	111·95	111·5	80	99·38

dimensions not being again repeated till No. 100 appeared, thirty years later.

Ivatt's "Atlantic" Design

The new "Atlantic" passenger engine No. 251, designed and built at Doncaster for the Great Northern, was in a great measure based on Ivatt's first series of the same class which came out in 1898, and already referred to by the writer in THE ENGINEER of July 16, 1948. The chief difference lay in the boiler, which was much larger and had a wide firebox extending over the frames ; in fact, it was largely this feature that attracted universal attention to the new locomotives.

With a total heating surface of 2500 square feet and 30·9 square feet of grate area, the boiler designed for these notable engines was then the largest in the country. The cylinders, of very moderate dimensions, remained as for the earlier "Atlantics" of 1898, being 18½in by 24in. The diameter of the coupled wheels also the boiler steam pressure were as before, these particulars being 6ft 7½in and 175 lb per square inch respectively. Stephenson's valve gear directly operated semi-balanced open-backed valves giving a free exhaust again, as previously used.

Drawings of the engine as originally built, appeared in THE ENGINEER of November 27, 1903, and, as subsequently modified by the fitting of a flue tube superheater and new cylinders, 20in by 24in with 8in piston valves, in the issue of November 28, 1913.

When Monsieur Edouard Sauvage read his paper on "Compound Locomotives" before the Institution of Mechanical Engineers in 1904, H. A. Ivatt gave some particulars of the performance of engine No. 251, which were reported in THE ENGINEER of April 22nd of that year.

Copies of indicator diagrams and related data showed that at 75 m.p.h. on a falling grade of 1 in 264 the engine developed 1194 i.h.p. when the initial and mean pressures were 125 lb and 57·7 lb per square inch and at a lower speed of 45 m.p.h. on an up grade at the rate of 1 in 200 the i.h.p. was 965, the initial and mean pressures being respectively 140 lb and 79·25 lb per square inch. The initial pressures quoted are computed from scales of pressures shown against the reproduced diagrams.

The two notable locomotives form an interesting contrast showing the ideas of two well-known designers. Such being the case, the table giving their leading particulars will have added significance.

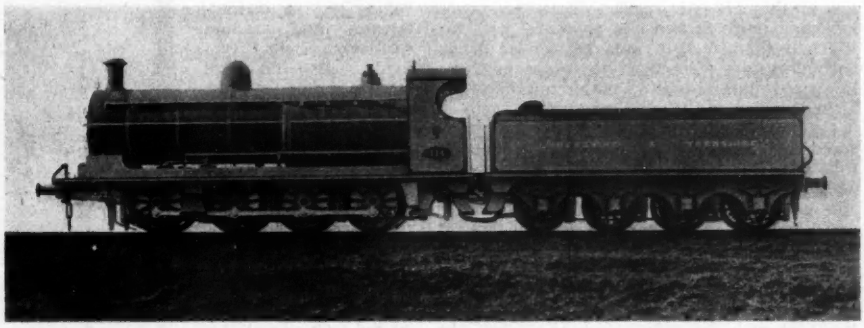
In all, ninety-three of the G.N.R. "251" class "Atlantics" were built, two of which Nos. 292 and 1421—were four-cylinder compounds. The standard simple engines were the mainstay of the important East Coast Joint and G.N. passenger services for many years, while the engine No. 100 was the forerunner, with modifications, only of the remarkably successful two-cylinder 4–6–0 engines later built at Swindon for main line fast passenger traffic.

Holden's Experiment

The experimental ten-coupled tank engine built at Stratford late in 1902 was in some respects a bold venture. It was designed to operate an intensive local passenger service on the Great Eastern with the idea of providing rapid acceleration combined with heavy train operation. To this end three cylinders were adopted in conjunction with ten coupled wheels, steam being obtained at 200 lb per square inch pressure from a huge boiler having a total heating surface of 3010 square feet and a grate area of 42 square feet, obtained by using a wide firebox.

The weight of 80 tons all available for adhesion concentrated on the wheelbase of 19ft 8in gave the very high loading of 4·06 tons per foot run of wheelbase, which seems to have proved too much for certain parts of the line, so that, although so far as power output was concerned, the engine met requirements, it could not be put into regular service. Thus ended a bold experiment of years ago and a design of very considerable interest, possessing features displaying undoubted ingenuity on the part of the Stratford drawing-office.

To those interested in the more recent development of the three-cylinder simple expansion locomotive, Holden's engine should always be remembered as the first modern adoption of this cylinder arrangement, being the first to have three cylinders since 1868, when one of the kind was built for the Blyth and Tyne Railway.



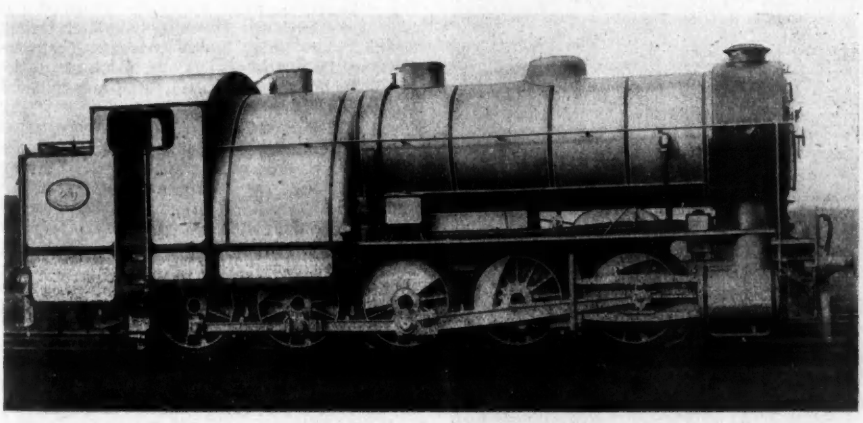
Hoy's Eight-Coupled Freight Locomotive with Cylindrical Firebox, Lancashire and Yorkshire

For Holden's engine the three cylinders, 18½in by 24in, were placed in line, the outside pair driving the centre pair of wheels. The inside cylinder drove the second pair of wheels through the medium of a single-throw crank axle having Worsdell's circular crank webs. A detail of special moment was the centre connecting-rod, taking the form of a more or less triangular frame which embraced the leading axle slightly cranked at its centre for clearance purposes. This very interesting engine was fully described, complete with arrangement drawings, in THE ENGINEER of February 6, 1903.

Hoy's Modified Boilers

The modified boilers first built at Horwich by H. A. Hoy in 1912, had cylindrical fireboxes fitted with circular corrugated flues, very much like the form of boiler tried by Vanderbilt on the New York Central in the United States. The Hoy design consisted of a boiler with a barrel section containing the tubes, having an outside diameter of 5ft 5¼in, and a length of 12ft 9in, united to a circular outer firebox 6ft 8⅛in diameter with its centre line 5 3/16in below that of the barrel. The inner cylindrical firebox, of the Fox corrugated design, had its centre 7½in below that of the outer casing and had a diameter outside over the corrugations of 5ft 1½in and a length of 9ft 6in.

The grate was fitted in the internal flue and a bridge of firebrick was built across



Holden's Suburban Tank Locomotive, Great Eastern Railway

the flue at the end of the grate, a short distance in front of the circular tube plate, in which was fixed 280 2in tubes. The total heating surface was 1890 square feet, made up of 1775 square feet for the tubes and 125 square feet for the firebox. The area of the grate was 26 square feet. The working steam pressure was 180 lb per square inch.

Though a number of the standard 0–8–0 freight engines were built and fitted with these boilers, they do not appear to have been really successful. The cylindrical furnaces do not seem to have kept their shape against the loadings imposed by the steam pressure and this, with other defects fully dealt with by George Hughes in his paper read before the Institution of Mechanical Engineers, 1909,* led to the design being given up in favour of the normal type of boiler which it was intended to displace. Thus ended yet another attempt to supplant the Stephenson locomotive boiler first applied when the "Northumbrian" locomotive was placed on the Liverpool and Manchester Railway in 1830.

The writer is indebted to British Railways (Western Region) for the photographs of the engine "William Dean" and the other illustrations are from photographs supplied by The Locomotive Publishing Company Ltd.

* "Locomotives Designed and Built at Horwich," Geo. Hughes. Institution of Mechanical Engineers, 1909.

Aircraft Tyre Testing

DURING a recent visit to Fort Dunlop we were acquainted with some of the newer problems affecting aircraft wheel tyre design and we saw demonstrated a recent installation for testing tyres at relatively high speeds. The thin swept wing of high-speed aircraft is primarily responsible for two of the major problems which beset the design of its wheels and tyres. In the first place, to avoid weakening the basic wing structure, leg and wheel size is restricted, resulting in thinner and smaller wheels and tyres incurring much higher tyre pressures, a factor which is aggravated by even heavier leg loads. Secondly, such wings tend to compromise the low-speed characteristics of the aircraft, imposing higher landing and take-off speeds.

Common loading details for a typical high-speed aircraft a few years ago might have been as follows: wheel load, 3½ tons; tyre pressure, 75 lb per square inch; maximum contact speed, 100 m.p.h.; the tyre being about 32in diameter and 10in wide. For the tyres which it is thought must now be investigated tyre pressures of 250 lb per square inch and landing speeds of 220 m.p.h. are envisaged with tyre diameters in the region of 24in and thicknesses no greater than 5in and, furthermore, of about half the weight. Already for one prototype machine wheel speeds of 170 m.p.h. have been encountered.

Tyre Testing Installation

The new test machine is thought to be the fastest of its kind in the world, with a maximum speed of 300 m.p.h. It has been designed and developed to reproduce landing, taxi and take-off conditions for aeroplane tyres of present and prototype jet aircraft up to 3000 r.p.m., and it can accommodate tyres ranging in size from 17in to 37in tread diameter under loadings up to 8 tons.

For many years an entirely different type of machine has been used at Fort Dunlop for testing racing tyres up to 420 m.p.h. This latter machine was designed for testing tyres with very low "drag" or rolling resisting characteristics, and needing relatively light tyre loads. Its 150 h.p. electric motor was just adequate, and there was thus no possibility of redesigning this machine for high-speed testing of aero tyres.

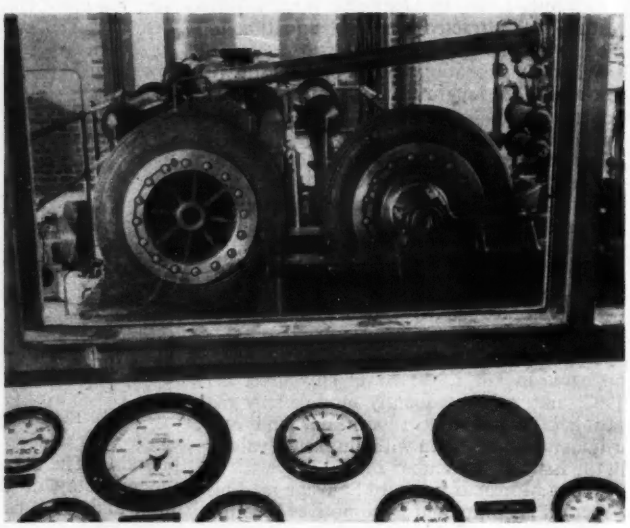
On the new machine, tyre loading conditions are provided by a pneumatic cylinder operating at a maximum pressure of 300 lb per square inch. Two tyres are tested in contact with each other, the one wheel/tyre assembly being attached to an overhung power spindle, the other assembly being carried on a dead spindle on the stroking saddle of the machine, as illustrated.

The test installation is driven by a Rolls-Royce "Merlin 724.S." engine installation, incorporating oil and coolant heat exchangers, water-cooled exhaust systems. The maximum power output from the engine is 1725 b.h.p. at 3000 r.p.m., with a sustained output of approximately 1300 b.h.p. at 2850 r.p.m. Exhaust ignition harnesses adjacent to the stubs are cooled by individual blowers, and all trenches are subjected to depression to minimise the risk of fuel/air mixture being present above floor level. Engine starting is by means of portable rectifier equipment.

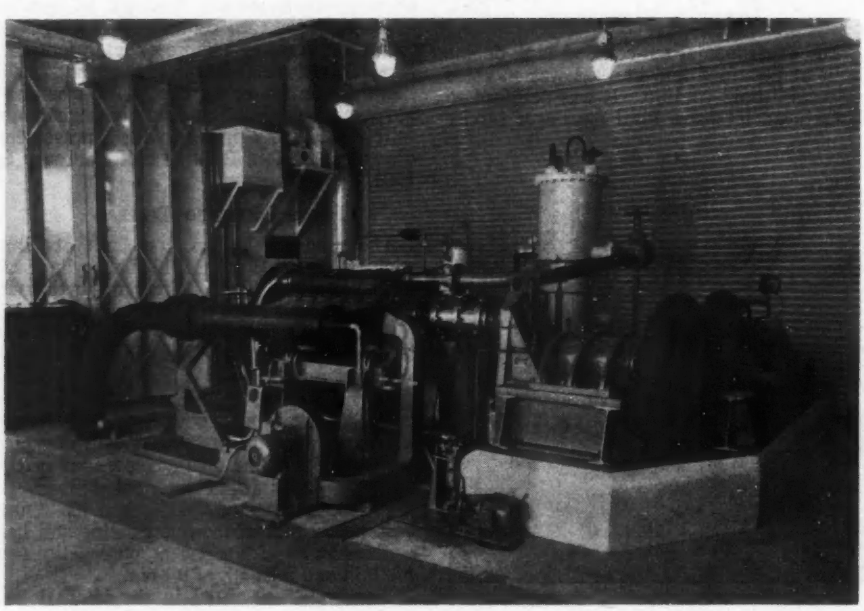
An increasing gear enables engine crankshaft speed to be obtained on the power spindle of the test machine.

All engine and test machine controls are contained on a main panel housed in the control room and, as illustrated below, viewing of the test is through a double armour plate glass window situated parallel to the longer axis of the test machine bed. The landing test sequences are automatically controlled to simulate impact loading, load relief on "float" of the aircraft, and resumption of the load equivalent to the static weight of the aircraft for a period corresponding to that of the aircraft rolling to a standstill.

Between 1000 and 3000 r.p.m. the throttle control is through the medium of a de Havilland airscrew constant-speed unit, which delivers oil to a servo cylinder incorporated in the throttle link.



Test Installation as seen from Control Panel



High Speed Tyre Test House

An electronic cut-off is designed to earth both magnetos when a crankshaft speed of 3080 r.p.m. is attained.

The engine output of 1725 b.h.p. illustrates the large amount of power to drive two relatively small tyres, which by their construction and high deflection during running have high rolling resistance or "drag" characteristics. Temperatures in the region of 150 deg. Cent. are registered within the tyre tread, after a simulated landing run. In order to be run at a steady speed of 240 m.p.h. the largest tyre to be tested on this machine would, for instance, need more than 500 h.p. The sudden application, as during a landing test, of a drag load of this order necessitates therefore a large reserve of power to ensure reasonably constant speed. Acceleration under loaded running conditions also demands a considerable power excess. The use of a power unit of this kind has many advantages. It is small, gives the required speeds with a minimum of transfer gearing, gives an extremely flexible drive, and is a self-contained power unit. The last two points are of great significance when considering the major alternative of electrical drive. The use of electric motors as the driving units would have entailed very expensive installation and would have increased the peak loads on the factory, already very high, by some

10 per cent. In addition, rapid speed variations essential for the tests are not readily available using electric drive.

Testing

Hitherto tyre performance data under the extreme conditions of service of high-speed aircraft could be got only from actual service, a method which is far from accurate. With the new machine, tests can be undertaken speedily under accurately reproducible conditions of test and in complete safety. In addition, many aspects of tyre behaviour can be studied under running conditions which it would be difficult to observe in actual practice: for example, centrifugal growth, tyre distortion during impact, stationary wave phenomena, and variation of tyre deflection due to centrifugal stresses, all of which are of vital importance in tyre design.

During take-off test cycles the tyres will be fully loaded against each other and the tyre speeded up to take-off speed, decreasing the load to zero during the process.

In landing tests the driving tyre is set spinning at landing speed; the idler tyre, at rest, is then rammed against the driven tyre for a short period, retracted for a further short period to simulate "float," and then reloaded during the run-down period. Automatic timers can be preset to govern the three stages of this test cycle. With pneumatic loading it is not possible to reproduce the landing cycle exactly; the initial "bounce" part of the cycle takes about two to three seconds on the machine, rather less in service. This is not an important difference, since it is the high shear stresses produced in the tyre when it is instantaneously jerked from rest to landing speed that must be produced, together with the ensuing high impulsive load. During the running down part of the landing cycle the test departs from reality, in that the engine is used to bring the tyres to rest; this is unavoidable, since it would be impracticable to brake the idler wheel against the driving wheel, i.e. against the engine. The new machine was not designed to carry out any form of braking, i.e. energy absorption tests.

Taxi-ing tests are carried out at relatively slow speeds under full load, with brief acceleration bursts. These tests are generally of longer duration than take-off or landing cycles and are a major part of the time, during the life of a tyre, when it is undergoing heavy flexing stresses.

The tests as proposed at present have been designed on the basis of speeds and tyre loadings as specified for the appropriate aircraft. Some of these aircraft are as yet in the early prototype stage and it is likely that testing speeds may be rather higher than will be regularly manifest in service. These tests will provide rapid assessment of casing structural performance, tread to casing bond strength, bead movement, tyre growth (actual), and temperature generation in addition to the items of performance already mentioned.

Electronic equipment has recently been installed to enable approach velocities of the idler tyre to be measured; this equipment will also enable some measurements of tyre deflection and centrifugal growth to be made pending the installation of optical equipment early in the New Year.

It is proposed to modify the compressed air circuit to give two loading pressures; by this means a heavier "bump" load will be possible for the first part of the landing to be followed by the remainder of the cycle, as previously outlined. This is an essential step, since the idler tyre assembly has very much less inertia than a landing aircraft.

Test Wheels

The present emphasis is on the testing of tyres rather than wheels, and for this reason special steel wheels have been designed to stop possible wheel failures during tyre tests. The equipment also includes a range of idler spindles to accommodate actual aircraft wheels for all the tyre sizes to be tested on this machine.

The use of solid steel wheels does, of course, cause enormous shear stresses to be set up in the tyre on the initial impact of the landing test due to the very high inertia of the wheels. Precise calculations of the instantaneous torque necessary to jerk the idler tyre into motion are not possible at this stage, but the magnitude is such that the engine speed, without the constant-speed unit, is brought down from near its maximum speed almost to stalling speed. Using a standard aircraft wheel for the idler tyre under the same conditions the effect on engine speed is very small. Tread "wear" has already been shown to be rapid under landing test conditions using the steel wheels.

In the test house, when a test is in progress, two large roller shutters, forming almost the entire length of the two side walls, are opened to dissipate the effects of blast, and a heavy curtain of 4in grommet torpedo netting, extending from floor to ceiling, surrounds the tyre mountings on the machine.

Because of the possibility of the tyres catching fire and of the dangers arising from the use of high-octane fuel, an elaborate CO_2 fire prevention system has been installed. Operated from the control room, this system can envelop the engine and tyres and fill the service trenches with CO_2 vapour.

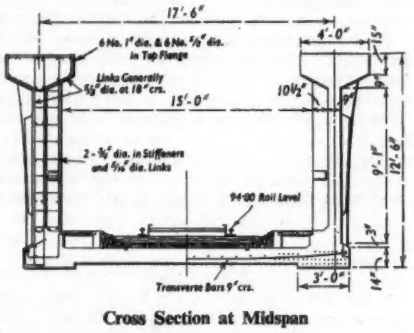
A Prestressed Concrete Railway Bridge

A single-track railway bridge with a span of 160ft has recently been built across the River Don at Rotherham. The bridge is a prestressed concrete structure embodying the Lee-McCall system, and is probably the longest span railway bridge constructed in prestressed concrete.

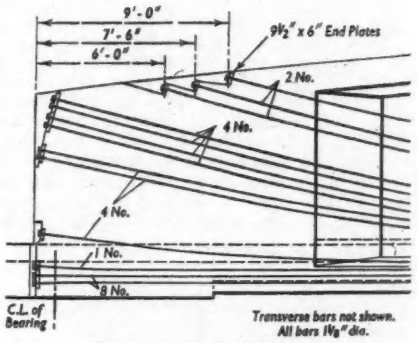
THE new railway bridge across the River Don has a single 160ft span with a large skew of 58½ deg. and carries a single line of track joining industrial sidings on each bank of the river. When in flood the River Don has been known to overtop the banks on this section and it has been necessary both to raise the approach tracks on each side to allow the underside of the deck to be kept above flood level and to use a shallow deck thickness. If a central pier had been provided in the river the obstruction to the flow so caused would have required a local widening of the waterway. It was, therefore, found to be more economical to provide a single span structure, the extra cost of the main girders being less than the cost of the central pier and river widening. To keep the raising of the approach tracks to a minimum a very shallow construction depth was required, so that the design consists of a thin deck slab spanning between deep parapet girders.

The plan, elevation and cross section of the bridge can be seen in the accompanying illustrations; the main girders are 4ft wide, 12ft 6in deep at the centre of the span, reducing to 9ft deep at the supports. They are spaced at 17ft 6in centres and the deck slab spanning between them is 10½in thick. Web stiffening ribs are provided at intervals between the deck slab and the compression flanges of the girders.

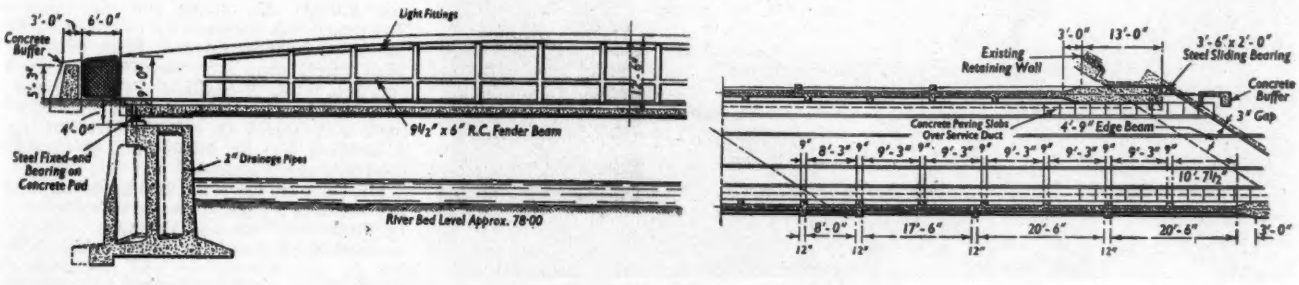
The bridge was designed for 20 unit live-loading in accordance with normal railway practice, providing for a standard train with 20-ton axles at 5ft centres plus a lower-than-normal impact factor of 17·4 per cent in view of the low speeds operating. The large girder depth was provided to reduce the deflection on the side of the deck opposite to the forward bearings of each skew abutment and this also reduced the steel quantities, the total weight of high tensile steel bars being only 28·4 tons. An additional 12 tons of mild steel



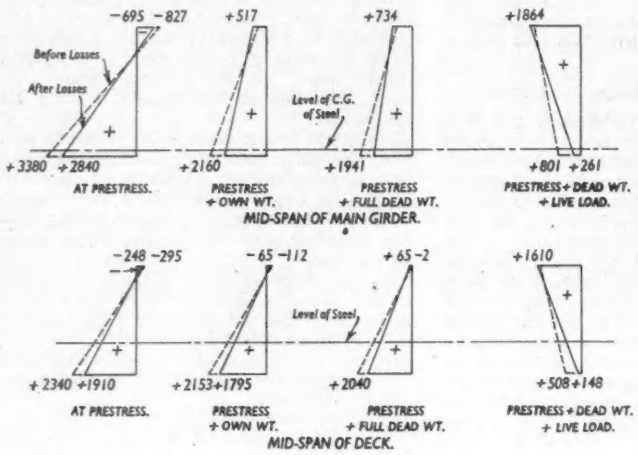
Cross Section at Midspan



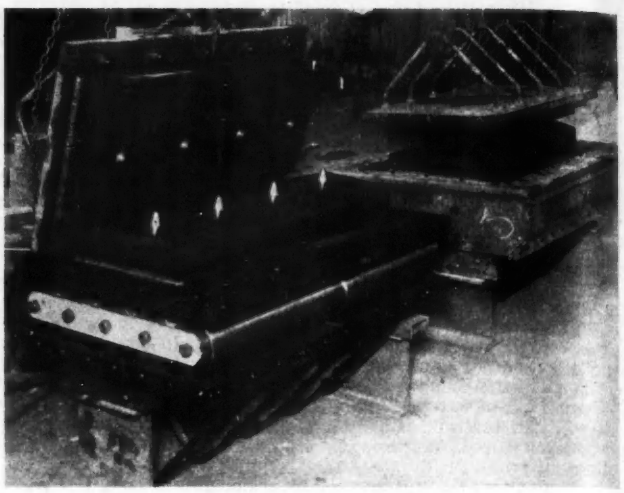
Detail at End of Girder



Details of Prestressed Concrete Railway Bridge at Rotherham



Stress Distributions



Combined Roller and Rocker Bearings

bars were required as reinforcement, mainly as stirrups and in the top compression boom of the deck, while a further 20 tons of mild steel reinforcement was provided in the abutments. The end anchorage plates for the 337 high tensile "Macalloy" bars had a total weight of 3·65 tons.

Foundations.—The abutments are cellular counterforts of reinforced concrete, supported on 8in by 5in R.S.J. piles, the foundations being taken down to a depth of 9ft below the river bed level. The concrete mix was 1 : 2 : 4 throughout with a maximum slump of 4in. The deck beams are carried on rocker bearings on one side and provision for stressing and thermal movement is provided at the other end by two combined roller and rocker bearings, which are shown in an illustration above. Each of these bearings carries a load of 300 tons and allows for a ¾in movement due to tensioning the steel bars, apart from the usual temperature movement.

Deck Slab.—With the girders spaced at 17ft 6in centres the deck slab gives more than the normal side clearance for extra wide loads. Concrete buffers for checking overhanging loads are provided just clear of the bridge structure. The 10½in deck slab is prestressed by 1¼in alloy steel bars at 9in centres, as shown in one of the illustrations. The stress distribution in the concrete deck at midspan, after allowing for full creep and shrinkage losses, was 1783 lb per square inch compression to 65 lb per square inch tension in the unloaded slab. With the dead load of the track the small tension was removed and with full live load the stresses reduced to 148 lb per square inch compression and 1610 lb per square inch compression at the top.

A drainage channel, 2in by 1in deep, is provided on each side of the track and the slab is drained from this through weep holes in the deck at 6ft intervals. Concrete paving slabs provide a walking platform on each side of the track and below them a service cable duct is provided.

Main Girders.—The disposition of the high tensile alloy steel bars in the girder beams may be observed from the illustrations. The stress conditions under dead load after full shrinkage and creep losses were compressions of 517 lb per square inch at the top and 1620 lb per square inch at the bottom. Under full load and impact these become 1864 lb per square inch and 261 lb per square inch compressions respectively. In assessing these values the steel has been ignored, but the effect of its inclusion would be small. This stress distribution is shown in a diagram above.

The maximum shear at the ends of each beam under full load is 325 tons, giving a nominal maximum shear stress of 404 lb per square inch. The maximum principal stresses are 1142 lb per square inch compression and 142 lb per square inch tension.

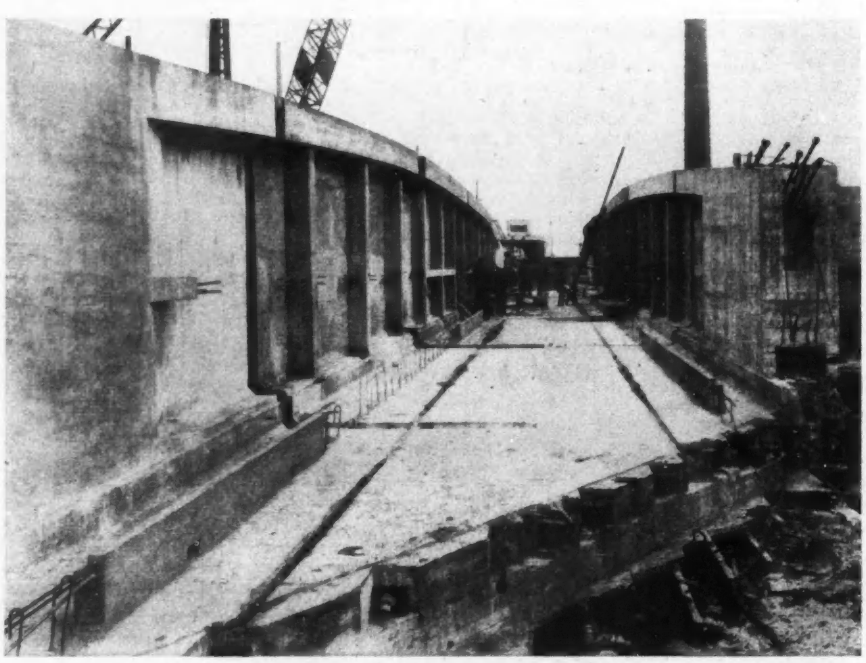
The calculated upward deflection of the structure on applying the prestress was 1·99in, which exceeded the calculated deflection under full dead load of 1·24in. A slight camber of 3in was provided in the span.

Concrete.—For the bridge superstructure the mix was 112 lb of rapid-hardening Portland cement to 162 lb of sand with coarse aggregate made up of 145 lb of ¾in down and 235 lb of 1in down to ¼in. The aggregate was almost entirely siliceous with reasonably rounded particles. The specified twenty-eight-day cube strength was 6250 lb per square inch and the actual test cube strengths obtained varied between 7000 lb and 8000 lb per square inch with occasional higher results. The water/cement ratio for the deck slab and the compression booms of the girders was 0·38, which was increased to 0·42 at the bottom of the girders where the closeness of the rubber tubes forming the ducts and the secondary mild steel reinforcement made flow and compaction under vibration more difficult. The concrete was compacted by a combination of one electric hammer on the formwork and two immersion vibrators, while the test cubes were compacted by electric hammer. The ducts for the high tensile alloy steel bars, 337 altogether, were formed partly with soft rubber tubes with a loose bar inserted and partly with inflated "Ductube."

In order to insert the bar couplers and to reduce shrinkage tension in the concrete before stressing, the girders and the deck slab were concreted in six sections with gaps between. This stage of construction is shown in the illustration below. The gaps were concreted after the bars had been placed and the couplers correctly screwed on and wrapped to allow the necessary movement during stressing. The bulk of the concrete thus had ample time to harden so that shrinkage and creep losses after stressing were kept as low as possible, and stressing of the girders was allowed seven days after concreting the gaps. The bars were grouted immediately after prestressing.

The accepted tender for the complete bridge was just under £34,000, of which £14,000 represented the cost of the abutments and piling and £20,000 the staging and superstructure. The design was prepared by Donovan H. Lee, consulting engineer to Steel, Peech and Tozer. The general contractor was George Longden and Son, Ltd., of Sheffield. The high tensile alloy steel bars for the prestressed concrete were made and supplied by McCalls Macalloy, Ltd., of Sheffield, and the bridge bearings were supplied by Joseph Westwood and Co., Ltd.

Mr. Donovan Lee mentioned the bridge during the course of a paper presented yesterday at the Institution of Structural Engineers. The estimated saving in cost of the whole bridge, including the pile foundations and abutments, he noted, was not less than £7000, by using prestressed concrete instead of structural steel.



Bridge Girders before Concreting Construction Gaps

Research and the Engineering Process

By H. E. MERRITT, M.B.E., D.Sc. (Eng.), M.I.Mech.E.*

The paper, of which long extracts are here reprinted, was presented last Tuesday before the Automobile Division of the Institution of Mechanical Engineers. It has relevance, however, far beyond the bounds of automobile engineering alone. The paper, in fact, represents a broad commentary on the development of research and on the part it has played in the evolution of the engineering process.

Introduction

A GREAT deal has been said and written about research, mostly by scientists for audiences well informed on scientific matters, but the application of research or scientific method to the needs of everyday engineering design receives less attention. This may account for the unbridged gulf which so often exists between the design office and the research establishment. It has been remarked, more than once, that important discoveries made in Great Britain too often have to go to the United States for their development, and it is probable that there is a host of other cases in which the results of research are not applied as quickly or as well as they might be.

There are, of course, branches or derivatives of mechanical engineering which necessarily rest on a solid scientific foundation, and these are usually conducted in very large organisations which are adequately equipped for research. But for every one such organisation, there may be a hundred small concerns which have neither time nor money to devote to research, or else have no inclination to do so. One of the means for applying more research to industry (and the most effective means so far devised) is the Research Association movement, but although it has made very great strides it still has a very long way to go. It will go further only as fast as the aim and purpose of a research association are understood and supported by the industry which it exists to serve.

This paper was originally conceived in terms of the automobile industry, not because the author believes that industry to stand more in need of research than any other, but because the paper is presented to the Automobile Division of this Institution. The general principles are common to all the other branches of mechanical engineering.

The Use of Words

"Engineering," from its liberal definition of "the art of directing the great sources of power in nature for the use and convenience of man," is now increasingly widely used in industries making engineering products (and particularly in the motor industry) to denote the collective activities by which the design of the product is determined. It is the sequence of those activities which the author here describes as the "engineering process." This term has been adopted in order to avoid the use of the word "design" in the sense of the "process of designing," which conveys too strong a suggestion that a "designer" can always be clearly identified and that his task is essentially an individual one. This is true in the case of the fine and applied arts in which a design is the work of a particular artist from the initial broad conception to the final execution of detail; and it is also true of some engineering products. In a complete machine such as a motor vehicle, however, the design may start only with a broad directive, and, in the hands of a number of specialist engineers working in parallel, may pass through many stages of investigation, scheming and testing before final acceptability is achieved.

The word "development" is also a source of confusion. In chemical engineering, for example, a process may be devised on a laboratory scale; the extension of the process to full-scale conditions is then commonly called "development." In the evolution of engineering products the word is used in two additional senses, one relating to the perfecting of an existing design by the improvement or refinement of detail, and the other to the larger step of creating something quite new.

It is when we come to "research" that clarity is most needed. The word "research" as used in the title of this paper stands for a methodical quest for knowledge and understanding. There is no doubt about the way in which this description applies to the work of a laboratory or establishment equipped for study in a branch or related branches of the physical sciences. It can be justly applied to any other kind of study, not necessarily requiring laboratory facilities, which seeks demonstrable facts and the laws or relationships which connect them; as, for example, to serious historical research. It is applied more questionably to the mere process of fact-finding, unaccompanied by a search for an understanding of the significance of the facts learned.

In its broadest sense, research is something which could be brought to bear upon every kind of creative activity. A "research department," therefore, does not exist to carry out, in a larger organisation, every job which could be described as research, but only research in defined fields for which it is appropriately staffed and equipped. The kinds of task assigned to a research department depend upon the kind of organisation of which it forms part.

A broad division can be made between (*a*) manufacturing concerns which make finished engineering products, and (*b*) those which produce raw or semi-finished materials or domestic or consumable products. In the first category, a "research department," if it exists, is only one of the elements of the whole engineering department in which final designs of product are determined. In the second category, the devising of the process or the product, or both, the department responsible is commonly called the research department.

These varying usages present no problem within a given organisation, if the terms of reference of the research department (whatever its scope) are defined and understood.

The Evolution of the Engineering Process

In the preceding paragraphs, no detailed explanation of the engineering process was attempted; the process has not yet acquired a standard form, but its nature can, perhaps, best be seen by a brief historical review.

Engineering began with palæolithic toolmaking, tools including weapons. The making of these tools, whether of flint or, later, of bronze or iron, required two things which are still amongst the three prime essentials of engineering. The first was a knowledge of materials; of the ways in which they responded to manipulation or reacted to the forces of circumstance. The second was inventiveness, or the ability to select from known facts a new combination having new possibilities, that is, a new idea.

One imagines that early knowledge of materials, whether of the ways in which they could best be worked or of their properties in service, came in small part from accidental discoveries and in large part from frequent and unwelcome failure; but that within the narrow scope of a particular material used for a particular purpose, the technique of a handicraft would become stabilised. Successive discoveries of new materials, however, offered new scope for inventiveness both in the processes by which the materials could be worked and in the uses to which those materials could be put. Under the first heading one may refer to lost-wax bronze castings made by the Sumerians around 3000 B.C., and, under the second, the diamond tools mounted in copper used by the Egyptians for sawing stone.

The relative slowness (by our modern standards) of progress up to the end of the Middle Ages was due to two things. The first was the illiteracy of craftsmen, so that knowledge could be transmitted only by word of mouth; the second was the reluctance of most early philosophers to carry out practical experiments. Engineers before Newton, and many after him, devised their appliances by the light of mechanical aptitude, which consists largely of the power of visualising the way in which mechanisms will behave, coupled with an intuitive sense of the character of materials. The first example of adding a theoretical approach to mechanical design appears to have occurred in horology; the discovery and application of the properties of a pendulum, devices for making the frequency independent of amplitude or of variations in temperature, and all the other achievements of the great clockmakers of the seventeenth century, reveal the new impress of science upon engineering. They also demonstrate another new element in mechanical design, namely, that the performance of a mechanism should be predictable.

In the application of mechanical engineering to domestic or local industry, the lack of means for communication remained a considerable barrier to the spread of knowledge, and the influence of scientific study was slower to make itself felt. Even after the proliferation of machinery by the advent of steam power, the millwright relied mainly upon craftsmanship, inventiveness and mechanical aptitude; not much more than a century ago there were vigorous (but often fallacious) arguments about the relative merits of involute and cycloidal teeth, but millwrights in Lancashire preferred to make their cogwheels of the "bay-leaf" pattern.

Still more slowly, because more difficult, came the beginnings of understanding of the nature of physical phenomena not visible to the naked eye.

The practical result of an understanding of invisible phenomena gained through research is outstandingly represented by the first great example, James Watt's invention of the separate condenser. The circumstances which led up to this invention, and the manner of it, are so well known that they need not be recounted here, but they constitute a pattern of long, unremitting study and sudden illumination which appear to characterise all discoveries. An even more spectacular result of scientific study led to the creation of an entirely new branch of mechanical engineering (if our sister Institution will allow the description), in the use of electricity, based on the accumulated researches of Faraday and his successors.

Not every piece of engineering represents the application or the consequence of pre-acquired scientific knowledge. The engineer, with all respect to the pure scientist, sometimes takes the first step; nevertheless, once feasibility has been demonstrated by the pioneer, the subsequent pursuit of perfection now increasingly demands scientific study, first to elucidate the basic new principles involved and then to contribute to the perfection of detail.

Revolutionary changes or developments, springing from new discoveries or great inventions, happen about once every generation; but less notable, although real, advances are made every day. Great or small, each is the result of a new combination of facts emerging from those in the mind of the inventor. Amongst these facts, the proportion derived from the physical sciences is steadily increasing; but this is not all. Most pieces of engineering are for the personal use or convenience of man, and they ought, although often they fail, to satisfy not merely the technical requirements, but also the natural dimensions, attributes, and abilities of the people who use them. This is particularly true of machinery for personal transportation, and adds, to the range of knowledge of which the engineer must take account, the developing science of experimental psychology. This branch of science represents, in elementary terms, no more than a study of how human beings perform, behave, or suffer; in relation, for example, to the identification of indicating devices, the response to signals, the operation of controls, the factors which influence comfort or fatigue, the effects of age, and so on. All these things have a very practical bearing on engineering design, and it takes very little observation to show how much they are neglected.

Research and Scientific Method

The transformation of our material equipment and surroundings during the last two centuries derives directly from the work of engineers, and, at one further remove, from research. The part played by research is of three kinds.

The first and obvious one is the provision of data, whether of single facts or of natural laws or relationships, which make calculation and prediction possible. It is easy to forget that the engineer's stock-in-trade of methods of design calculation, from arithmetic upwards, represent the accumulated research of centuries.

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The second effect of research (without which the mere provision of data can be misleading or dangerous) is to provide not only a knowledge of phenomena, but an explanation. The ultimate understanding of many of them (such as electricity) may not yet be in sight, but "engineering" explanations, by which measurable causes can be related to measurable effects, are the foundation of efficient mechanical design.

The third effect of research is the least visible and the most potent, because it relies upon a new approach to the search for truth, called scientific method. It might be helpful if this term could be generally construed not narrowly as the method used by scientists, but as the method which must be used if accurate, organised knowledge (science) is to be acquired. It need not be exclusive to those who by the nature of their work or calling are identifiably scientists.

This scientific method first requires that its practitioner should be a genuine seeker after truth. This is a very difficult thing to do, because it involves discarding favourite prejudices, resisting the temptation to ignore evidence unfavourable to a preconceived notion, and insisting on measurable facts. This approach, not easily acquired even in the laboratory, is more difficult to adopt in the hurly-burly of industrial life, and requires the discipline of training.

Not everyone who contributes to the engineering process can be engaged upon what is recognisably research, but scientific method can be applied at every stage to every task, and unless scientific method or the research attitude is understood beyond the ranks of research workers themselves, the initiation or application of research by engineers will inevitably be retarded. The "bay-leaf pattern" will continue.

The Scope of Research in Engineering Problems

The engineering process is the process by which all the contributory technical resources—knowledge of materials and methods of manufacture, knowledge of the engineering sciences and related branches of technology, facilities for experiment or test, draughtsmanship, current practices and past experience—are combined to produce a design which satisfies a new external requirement or produces some new and worthwhile result.

The first step is a new idea which marries external requirements with the available internal technical resources. Knowledge of both sides must be present before the idea can be thought of, and study of the purposes for which a machine is required and the circumstances of its use is the first direction in which research (whether so-called or not) is necessary. This is not the same thing as what is usually termed "market research," which tends to be concerned with statistical studies of consumer preferences for specified types of product. External "user" research is wider in scope: it can cover physical operating conditions (as of vehicles in overseas territories), methods of operation or particular and local technical requirements; or it can go further, embrace the relationship of a machine to the total process of which it forms part (as in the case of farm machinery), and thence lead to an idea not of what the customer wants, but of what he would like if he saw it. It is suggested that not nearly enough research of this kind is done, by men competent to do it. This does not mean merely men qualified by scientific training to act as accurate observers and reporters; they must also have the other essential qualities of the engineer in order that they may recombine the results of what they see into new ideas.

The scope for "internal" research is much more diverse, since it could, if resources permitted, be applied to every detail at every phase of the engineering process. Work of a research character is involved whenever data which may contribute to a future design are being gathered or produced. Thus whenever the results of experimental or test work are analysed, failures are being studied, past practice of one's own or of competitive products are being compared, or publications are being read, in each case with the object of reaching generalised conclusions for future use, research is being done. These examples, however, represent only one of the many gradations of research; research seen *in toto* can be classified either by its character or by the place in which it is done; to some extent the various categories run together.

Categories of Research

The terminology is now fairly well established. "Fundamental" research is research which aims at acquiring an understanding of the inner nature of physical phenomena, without reference to any practical problem. It could concern such things, to quote only a few examples, as the phenomena of combustion, the mechanism of corrosion or of corrosion inhibitors, the nature of friction, or the ultimate explanation of the mechanism of the fatigue of metals. All of these are truly fundamental to nearly every piece of mechanical engineering; but none is yet fully understood, and some are hardly understood at all.

"Basic" research differs from fundamental research, by an arbitrary distinction between almost synonymous words. It aims at studying physical phenomena to such a degree that the circumstances in which they will occur, and their nature and effects, can be predicted, desirably in quantitative terms. The results are, therefore, of a quite general nature, and might find application to a wide range of future problems, but the work is not inspired by any particular problem.

Both fundamental and basic research are properly the work of specialised laboratories and require great freedom of thought and action, quite dissociated from immediate industrial exigencies. They are, therefore, mainly conducted in the establishments of the Department of Scientific and Industrial Research, the Universities and the Research Associations, although a number of large industrial undertakings also operate detached research laboratories for this kind of work.

"Applied" research is research directed towards the solution of a particular problem of practical importance. Any piece of work under this heading can, therefore, be initiated only when the existence of a practical problem is perceived, and it can be successfully concluded only when it is possible to see that the answer reached is a practicable one. Work of this kind can be, and is often, done by a Research Association when the problem, although specific and practical, is common to the industry which the Association exists to serve. This is of particular value when the industrial members of the Association are not sufficiently equipped for research, or are not sufficiently analytically-minded to perceive that a problem exists. It is one thing to have trouble and quite another to define the problem that underlies it.

But for every problem that is common to an industry, there are a host that are peculiar to the products of one company. These require domestic research facilities. Reference was made, earlier in this paper, to work of a research character which may be implicit in many engineering tasks; but other research work is best undertaken under conditions not circumscribed by day-to-day exigencies or design programmes; it may also require special laboratory facilities. Thus arises the domestic research department.

Making Use of Research

It is frequently pleaded, with a justice which the daily-apparent effects of past research abundantly confirm, that still more research ought to be done in this country. Equal priority, however, must surely be given to the problem of using the results of research work already done. To show the magnitude of this problem, it has been estimated that world publication of items of scientific import is at a rate approaching 1,000,000 per annum, but the publications remain useless until they are read by somebody who can use the information that they contain. The problem of securing this result, by means of classification, indexing and abstracting services, is formidable enough even in one narrow scientific field. It becomes even more difficult to serve the engineer, who has to draw upon so many branches of science. It is impossible to do justice to this side of the question here: it must suffice to say that whilst no one person can keep abreast of the times merely by the reading of periodicals casually circulated round the office, the latest information on any specified subject can usually be found if one knows where to go or whom to ask for it. The real problem, for the busy engineer, is to find the time to study all his problems with the care and thoroughness that they deserve—even the time to reflect upon the kind of information that might be available and the place from which it might be obtained. But if he has at his side a "research department," which includes amongst its terms of reference (as it always should) the provision of an information service, all that he has to do is to explain the nature of his problem and a digest of the relevant information will (or should) be forthcoming.

Information relates only to past work; it remains to consider requirements for new work and the way to get it done. Every piece of every kind of research work has its origin in the perception by somebody of a problem. In the case of fundamental research, the examples already quoted of combustion, corrosion, friction and fatigue are not related to any one class of machinery, but derive their importance from the fact that each is associated with the expenditure of very large sums of money over the whole field of engineering, on fuel, paint or replacement, power and wearing parts, and constructional material, respectively. Basic research being more closely related to particular classes of problem, the perception of desirable subjects for research comes from a more intimate knowledge of the factors by which current practice is limited.

This is why a Research Association has so great a potential value; for by its constitution it combines the detachment of a research establishment with close contact with the needs and opinions of its member firms. Whether the effectiveness of this combination changes from potential to actual depends, of course, on the ability of the member firms to make their proper contribution in the way of perceiving, analysing and explaining their problems to the research men. If they can do this, they are then equally able to appraise and apply the results of the research. What is needed is a link or interpreter; this is automatically provided when member firms have research departments of their own.

This link is the more easily established, the more narrowly the industry is concerned with a particular branch of technology. It becomes more difficult in the case of mechanical engineering, in which the problems, seen or unseen, cover so wide a field. Perhaps because so much in mechanical engineering remains empirical, and "text-book knowledge" plays so small a part in design, the scope for basic research often remains unperceived: this may be one reason for the lack of contact between industry and the universities and technical colleges. It all comes back to the same thing—to know what is wanted. This is equivalent to an acknowledgment of ignorance, which Socrates described as the beginning of wisdom.

Applied research is primarily a domestic affair and requires domestic facilities. It was remarked earlier that much of the day-to-day work of an engineering department may be said to be of a research character, but there are usually several problems which cannot be dealt with in this way, and these problems can easily be amongst the most important of all. Thus it is easy to design for the inclusion of mechanical features, but it is not so easy to design for the exclusion of undesirable phenomena, since this requires a much greater knowledge not only of what happens, but why it happens. The problems of noise and vibration in vehicles sufficiently illustrate this.

A great deal of time, thought and money are absorbed in the endeavour to overcome these and other undesirable phenomena, and this reduces the effort which can be developed to the search for improvement in the more technical sense. "Trouble-shooting" investigations are normally outside the province of a research association, partly because the cure must be sought within the limits of what is technically feasible to the manufacturer, and partly because the time available for the investigation, and the

scope or degree of improvement, may be determined by a production schedule.

Nevertheless, a group of problems arising out of similar products made by the same or by different companies may have much in common, and may converge at a point of basic or fundamental research best conducted in an independent research establishment. The result of the work, by revealing the cause or the mechanism of the trouble, may then enable the cause to be suppressed in a new design. Without this understanding the same trouble may have to be cured in a costly *ad hoc* way, on each of a series of new models.

Research and Creative Design

Research is described in this paper as a contributory element in the engineering process; the search for knowledge and understanding. The immediate object of research, or of a research association, is not, therefore, to produce new designs.

It can, of course, happen that if some new mechanical phenomenon is discovered, the design of a mechanism which will make use of the discovery will occur to the researcher. If the nature of the phenomenon is intricate or difficult to understand, the researcher may, in fact, be able to develop the design more readily than could another engineer to whom only the facts, without necessarily a full understanding, were communicated. It should also be said that creative imagination, which is essential to design, is equally essential to research, alike in forming the tentative hypotheses on which experiments are based, in devising the experiments themselves, and in interpreting the results, whilst the devising of experiments and apparatus requires the same mechanical aptitude as is necessary in engineering design. Methods of testing the relative merits of materials or components, and apparatus for that purpose, illustrate this case.

On the other hand, the embodiment of a discovery in a practical design may require additional knowledge and experience in directions unfamiliar to the researcher, or may have to await an opportunity over which the researcher has no control. He might, for example, acquire new knowledge on possible ways of reducing the resistance to propulsion or increasing the stability of a vehicle—knowledge which he is unable to apply himself, but which would be invaluable when the design of a new vehicle came to be undertaken by somebody else. These would represent examples of "basic research," in which one set of results could be made use of by many engineers, in the way best suited to the products for which they are responsible.

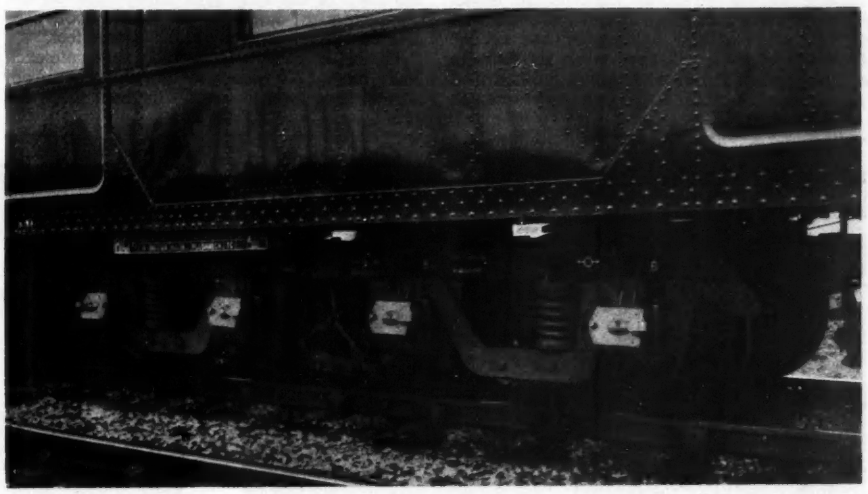
A Rail Track Testing Coach

During the next few weeks trials are to be conducted on the Western Region of British Railways with the Mauzin track testing coach owned by the French National Railways. These trials form part of an investigation being carried out in connection with track testing equipment, and the French coach will supplement the existing devices which have been in use on British railways for a number of years. Consideration is also being given to trying out in this country a recording coach of a different type designed by Amsler and Co., of Switzerland. It is emphasised, however, that these special vehicles only supplement, and do not replace, other track-recording devices already in use here. For many years the Hallade track recorder used in this country has been able to give a certain amount of information about track, but its accuracy is limited because the records it makes are affected to some extent by the characteristics of the coach in which it is carried. The French coach now introduced is designed to give fuller and more accurate information and to locate the exact spots where track defects occur.

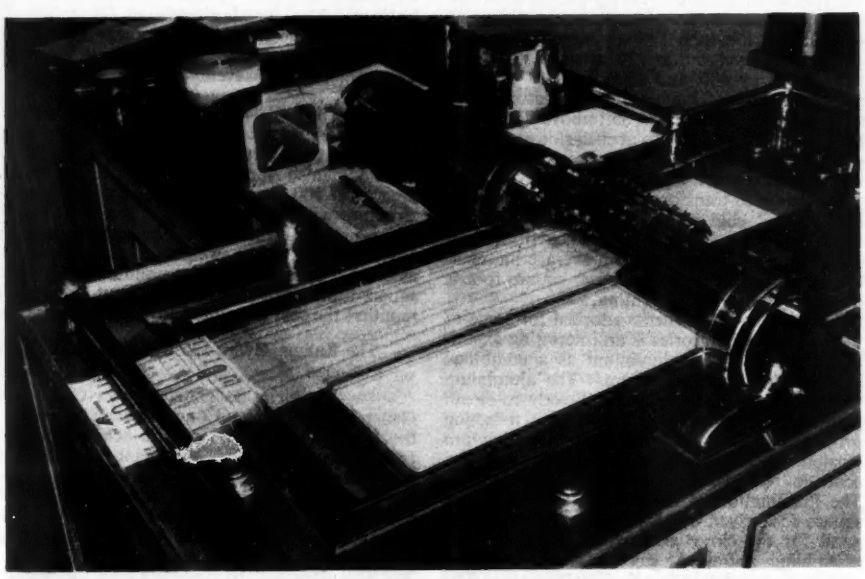
The Mauzin coach is similar in appearance to an ordinary French railway carriage except that it has sixteen wheels instead of the usual eight, there being a four-wheeled bogie at each end with an eight-wheeled bogie between them. The coach weight of about 50 tons gives a load of some 6 tons on each axle, which is sufficient to indicate whether the sleepers are properly packed with ballast. The central eight-wheeled bogie can be seen in one of the illustrations on this page and between the middle pair of wheels can be seen one of the sets of rail feeler discs.

The recording table in the coach can be seen in the other illustration. As the coach passes along the track a paper chart strip about 8in wide is drawn through the recording apparatus at a preselected speed set by means of a gearbox drive. Seven stylus pens, connected through a system of tensioned wires and pulleys to the axles or feeler discs touching the insides of the rails, rest on the paper. Fixed pens in front of the recording pens draw a series of datum lines on the paper. It will be seen that a second chart roll can be set on the apparatus below that being recorded. This lower chart can be of a recording taken previously of the same length of track, and as it runs through at the same speed comparisons can be made between the original and present conditions of the track.

The lines drawn on the chart by the pens indicate the relative levels of the rails; irregularities in the left-hand rail; irregularities in the right-hand rail; accuracy of gauge width; the variation of cant, or superelevation, on curves, and the degree of curvature. In the vertical direction records are obtained by comparing the level of one axle with the average level of the others. In the horizontal direction the transverse movement of a feeler disc in contact with each rail is compared with that of similar discs in front and behind. The chart has the mile post numbers marked on it as well as reference points, so that the actual location of any irregularities can be at once ascertained by the track maintenance staff.



Centre Bogie and Rail Feeler Disc Unit



Track Recording Table in Coach

Welding Research.—The October, 1952, issue of *Welding Research* contains reports on the "C.T.S. Weldability Test for High-Tensile Structural Steels" and "Surface Cleaning of Some Aluminium Alloys Prior to Spot Welding." The Controlled Thermal Severity (C.T.S.) test procedure has been based on the metal-arc welding process and the test based on work reported under the title "Correlation of Weldability Tests with Structural Joints." It is designed for testing material in the form of sections and plate from which only thin specimens are obtainable. Weldability for the purposes of this test is essentially the measure of the resistance of steel to the development of cracks in the joint, particularly in the heat affected zone adjacent to the weld bead. The second report by H. E. Dixon, M.Sc., deals with the pre-resistance welding surface preparation of 20, 18, 16 and 14 S.W.G. sheet of certain aluminium alloys. It covers work on spot welding of the alloys carried out by the British Welding Research Association, with the object of improving the consistency of spot welds by suitable control of the variables. Surface preparation, electrode contour, load cycle and secondary current wave shape were investigated.

Cold Cathode Lighting in an Engineering Works

A COLD cathode fluorescent lighting scheme, involving the use of more than 23 miles of cold cathode tubing, is now nearing completion at the Heaton heavy engineering works of C. A. Parsons and Co., Ltd., Newcastle upon Tyne. It is stated to be the largest lighting installation of its kind in the world. This scheme, which began as an experiment with G.E.C. cold cathode lighting in one of the foundries in 1947, will have taken six years to complete when the final section is finished next year. In this final section, a new research building, covering 120,000 square feet, troughed aluminium ceilings will be employed as a combined lighting and heating medium.

The lighting, which forms part of a general scheme of expansion and modernisation at the works, was planned by the engineering department of C. A. Parsons and Co., Ltd., in collaboration with the General Electric Company, Ltd., which supplied all the "Osram" tubes, lighting fittings and auxiliary gear. Up to the present a floor area of 454,000 square feet of engineering workshops has been illuminated under the scheme.

For the new lighting, a special heavy-duty fitting has been employed throughout, mostly with triple tube arrangement, but in some cases four tubes employed in the same fitting have been found both technically and economically more suitable. The fitting is completely self-contained with a three-pin plug and socket arrangement for connecting to normal lighting mains. The overall consumption of the complete three-tube fitting is 250W and standard "Osram" 9ft 6in intermediate colour cold cathode tubes, which have a lighting length 8ft 6in, are used throughout. Built in two 4ft 3in lengths, the vitreous enamel reflectors are easily removable for cleaning without removing lighting tubes.

In the heavy foundry, the average illumination given at floor level by fittings at a mounting height of 42ft is 10 lumens per square foot. Though the accumulation of dust on the tubes may reduce this illumination value after a few months, a twice-yearly cleaning is stated to restore it even now, after 9000 hours' burning, to 9 lumens per square foot.

The pipe division comprises three bays, 40ft 6in high from the normal floor level to eaves. Two of the bays are 450ft long and 60ft wide, and the third is 600ft long by 60ft wide. In this division, illumination for the total area of 92,000 square feet is provided by lines of cold cathode tubes mounted at a height of 35ft along the roof and at 20ft along the sides of each bay, the average level of illumination being 9 lumens per square foot.

In the condenser bay, fittings mounted at 35ft in two lines along the roof and at 22ft along the sides of the shop give an average service illumination of 9 lumens per square foot, over an area of approximately 21,000 square feet.

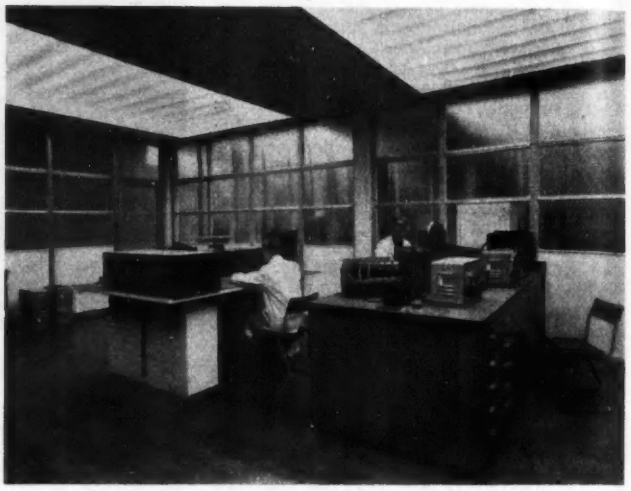
The blade rolling and assembly shops are each 360ft long, 57ft wide and 26ft 9in high from normal floor level to eaves. In these shops the general illumination, which averages 14 lumens per square foot, is stated to be such that no independent lighting is required on individual machines, although they are performing particularly intricate operations. In the annexe to these shops, where finished integral blades are ground and polished, the lighting fittings have been arranged at an angle inclined to the work to give maximum illumination efficiency.

Two heavy machine shop bays, filled with heavy machine tools and heavy cranes handling turbine rotors and stators, are 560ft long and 40ft wide, and have triple-tube fittings mounted at 35ft above floor level and at 22ft at the sides. Two bays, 400ft by 40ft and 430ft by 80ft, used for the assembling of large turbo-alternators, have similar fittings mounted at 35ft above floor level, and again a row of fittings at each side at a height of 22ft. One of these large assembly shops is illustrated herewith.

In the new transformer shop, although the five lines of cold cathode tubing are mounted beneath the roof and the distance from floor to eaves is 54ft 6in, a uniform average illumination level of 12 to 15 lumens per square foot is obtained without local lighting.

The new lighting scheme adopted for some of the research laboratories is an interesting experiment in the use of aluminium as a combined lighting and heating medium. The aluminium troughing, which is connected directly to steam pipes, is anodised to improve its light reflecting properties. Lines of cold cathode tubing are located in the aluminium troughs, and for acoustic reasons, the aluminium is perforated. The illumination of from 50 to 60 lumens per square foot given by this system is particularly good for the close work which is involved in assembling infra-red gas analysers, spectrometers and other scientific instruments. The ceiling arrangement in one of these four laboratories can be seen in our second illustration.

Cold Cathode Lighting of Turbo-Alternator Assembly Bay



Cold Cathode Lighting and Heating of a Laboratory

Continental Engineering News

(By Our Continental Correspondent)

High-Power Transmitting Station in Belgium

Recently the King of the Belgians opened at Wavre-Overijse, near Brussels, the new broadcasting station of the I.N.R. (Belgian Broadcasting Corporation). The new station, comprises a series of buildings covering an area of some 600,000 square feet. It is divided into three parts: the transmitter house, the power house and a wing for various auxiliary services, which connects these two buildings. All these structures have reinforced concrete frames and masonry walls. The main broadcasting building consists of two halls, each measuring 140ft by 105ft, one above the other. The upper hall is about 33ft high (without any intermediate support) and contains the broadcasting apparatus, while the lower hall, which is about 20ft high, contains auxiliary apparatus. There are four power transmitters (two for medium wave and two for short wave), with an overall power of 500kW for the four. There are three principal aerial masts for medium-wave broadcasting, which are respectively 804ft, 541ft and 295ft high. All three masts have, apart from the lowest part, a constant cross section, which consists of an equilateral triangle of various side lengths, ranging between 10½ft and 9ft. All the steel elements of the masts are zinc metallised, and the masts are held in the vertical position by holding cables, forming angles of 120 deg. with each other. Electric arc welding was used in the assembly process. Erection of these three masts was completed in seventy-two working days.

A Welded Steel Aircraft Hangar in Spain

A welded steel hangar was recently erected at the Cuatro Vientos Airport in Spain for the Spanish Aeroclub. The hangar covers an area of 27,000 square feet, and is a steel-framed structure with masonry walls. The front elevation is provided with eight sliding gates measuring 16½ft by 21ft. The weight of the steelwork, assembled by arc welding, amounted to 9 lb per square foot. Works were carried out in eighteen months; the cost amounted to 1,850,000 pesetas.

The Kalima Hydro-Electric Scheme, Belgian Congo

Monsieur de Thibault, Vice-Governor-General of the Belgian Congo, opened in October the new Kalima hydro-electric scheme on the Lutshukuru River. The new plant is some 200ft from the first Lutshukuru power plant, completed in 1944, and it utilises water from the first plant. Both plants are owned by the Symétain Company. A dam is also being built on the Lutshukuru upstream of the two existing dams. The new dam will be completed by the end of this year and its storage reservoir will hold some 5,000,000 cubic yards of water.

The Volta River Aluminium Scheme

Proposals for the development of a large aluminium industry in the Gold Coast, based upon a major hydro-electric scheme on the Volta River, have been published as a Government White Paper ; some abstracts from this White Paper are reproduced in the paragraphs below. The hydro-electric scheme would give, ultimately, about 564 MW of firm power, the reservoir covering about 2000 square miles. An annual production of about 210,000 tons of aluminium would, therefore, be possible. The scheme also includes the construction of railways and a port.

IN less than half a century aluminium has established itself as a major non-ferrous metal, and there is every reason to expect that the demand will continue to grow rapidly. The scale of the increase which informed opinion expects is illustrated by the recent estimate that the consumption of aluminium in the United States and the rest of the world in 1975 might be between four and five times the consumption in 1950. The Aluminium Industry Council (the representative body of the various sections of the United Kingdom aluminium industry) considers that, on a conservative estimate and on the basis that aluminium is available at competitive prices, United Kingdom requirements will increase at an average rate of 5 per cent a year over the period 1950–60. On the assumption that this rate of increase would be maintained over the full twenty-five years United Kingdom industry would require about three times as much aluminium by 1975 as was consumed in 1951, when consumption amounted to 316,000 tons (203,000 tons virgin metal, 113,000 tons secondary metal). There is bound to be a wide margin of error in estimates of the future demand for a commodity like aluminium, but these figures indicate the scale of the potential demand for a metal which on any reasonable view will be of growing importance in the national economy. The fabricating industry in the United Kingdom has already in recent years considerably expanded its capacity which now is about 500,000 tons a year.

It is not too soon to be looking ahead to the 'sixties and 'seventies. It necessarily takes a long time to provide the hydro-electric and other capacity involved by a major scheme of new development. For various reasons it is impossible to rely for the full additional needs of the United Kingdom upon existing sources of aluminium. At present the United Kingdom obtains more than four-fifths of its virgin aluminium from dollar sources, and it is important that additional supplies should come as far as possible from the sterling area. With existing processes there is little, if any, scope for further development of aluminium production in the United Kingdom itself, and careful examination of the possible alternatives elsewhere in the sterling area, in which the co-operation of Aluminium Ltd. of Canada and the British Aluminium Company has been of the greatest assistance, has led to the conclusion that the most promising site is on the Volta River in the Gold Coast. This does not, of course, mean that it may not prove necessary to develop further capacity elsewhere in the sterling area or that there may not even now be scope for smaller schemes.

The Volta River Scheme

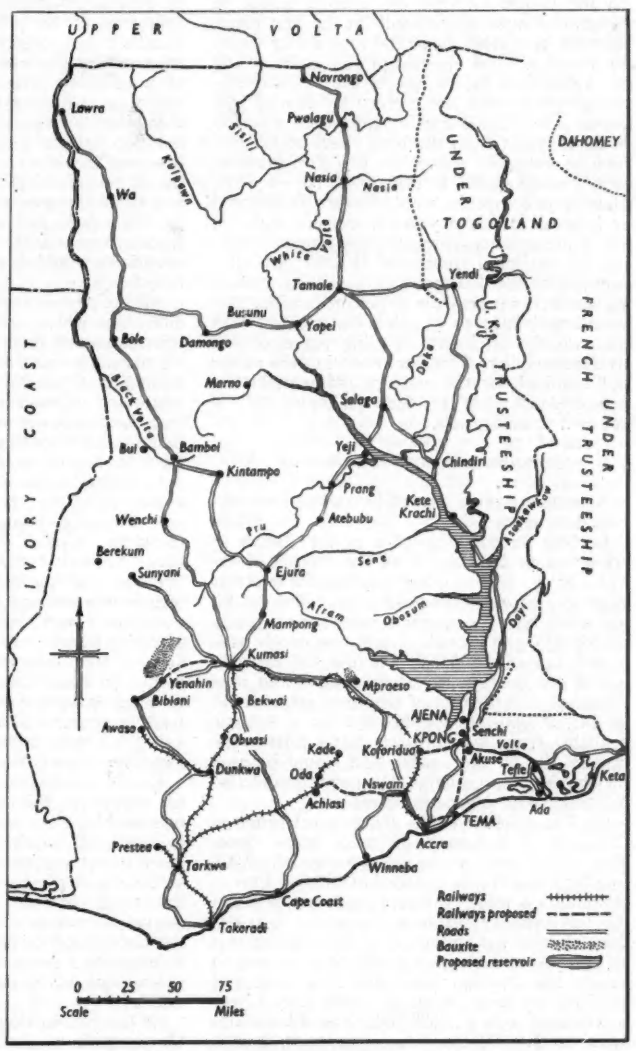
The Volta River, the principal river of the Gold Coast, has a total length of some 1000 miles from the head waters of the Black Volta to the sea. The drainage area of the river system is approximately 150,000 square miles, of which 61,500 square miles (roughly 40 per cent) lies within Gold Coast territory including the trust territory of Togoland, and 88,500 square miles lies outside the Gold Coast in French territory. The Black Volta rises in the French Ivory Coast and flows north-east and then south to form the western boundary of the Gold Coast Northern Territories, and thence east to join the White Volta some 300 miles from the sea. Below this confluence there are two main tributaries, the Oti and the Afram. The accompanying map shows the general geography and the places mentioned subsequently in connection with the scheme.

About 75 miles from its mouth at Ada the Volta passes through a low coastal range, the Akwapim Hills, the country up-river being flat. The gorge through the hills provides a possible site for a high dam which would pond the water up the Volta and Afram to form a great lake. The only other site apparently suitable for a dam on the river system is at Bui on the Black Volta, 145 miles upstream from its confluence with the White Volta ; this site would provide much less power. The scheme now proposed by the consultants, Sir William Halcrow & Partners, envisage the construction of a dam and power station at Ajena in the gorge through the Akwapim Hills. This would raise the water level to a maximum height of 260ft above sea level and would create a lake with an area of some 2000 square miles, as shown on the map. The geologists of the Gold Coast Government have agreed that the dam and reservoir proposed are geologically sound. The exact extent of the reservoir will not be known until a detailed survey has been completed, but it is known that the water can be safely raised to this level. From records of the river flow which are available over a twenty year period it is estimated that the discharge could be regulated to give a continuous rate of 35,700 cusecs. The draw down from the maximum level would be limited to 25ft. By cutting through the Senchi and Kpong rapids below the dam to lower the tail water level it is calculated that an output of 564MW of firm electric power could be developed.

It has always been realised that any major development of the Volta Basin would only be economic if an adequate demand could be found for the available power. Existing and estimated future demands for electric power in the Gold Coast are insufficient to justify the hydro-electric power without a heavy power consumer like aluminium production as the main outlet. It is intended to set up an aluminium smelter in the vicinity of Kpong, some 12 miles from the dam site. After allowing 50MW for other users in the Gold Coast, the power available from the hydro-electric installation would be enough to produce 210,000 tons of aluminium a year. The smelter would draw its major raw material, bauxite, from reserves within the Gold Coast. Deposits of bauxite at Mpraeso and Yenahin, which would be worked to supply the smelter, are estimated to exceed 200 million tons, sufficient for about 200 years' production at the maximum output of the smelter.

Public Works.—The establishment of an aluminium industry of this size would necessitate the construction of a new port conveniently situated to serve its needs. Takoradi is the only major port in the Gold Coast. Accra, next in size, has already reached the limit of its capacity and is unsuitable for further development as a port. While Takoradi has recently been extended, it is already evident that a new major port is urgently required to meet the general needs of the expanding Gold Coast economy. Sir William Halcrow and Partners recommended that a new port to serve both the general and the aluminium needs should be constructed at Tema, about 20 miles east of Accra. The Gold Coast Government, after obtaining a second opinion, have decided to proceed with the construction of a new port at Tema whether or not the scheme as a whole is undertaken ; preliminary work is now in hand.

In addition there would need to be a considerable development of communications. Existing roads would need improvement and new roads would have to be built. It is expected, however, that the main burden of new traffic would fall on the railways. The new port at Tema would have to be linked by rail to both Accra and the smelter at Kpong. The bauxite would also be moved by rail, and new lines from Yenahin to Kumasi and from Koforidua to Kpong would be required. The Gold Coast Government would be responsible for financing these public works and the townships which



Proposed Developments on the Volta River

would come into being at the port and the dam site. The work would be carried out by the appropriate Gold Coast organisations, e.g. the Gold Coast Railways Department, the Tema Development Corporation and the Public Works Department.

The Smelter and Mines.—The aluminium smelter and bauxite mines would be managed by private enterprise, the aluminium companies and the Gold Coast Government sharing in the provision of the equity capital. The smelter company would be responsible for the construction and operation of the smelter and the development and operation of the mines. The smelter company would also be responsible for constructing the townships at the smelter and mines. The land required for the smelter would be acquired by the Gold Coast Government and would be leased to the smelter company for a period of eighty years plus a period of not more than three years for the construction of the smelter.

It would be the intention of the aluminium companies to proceed to a smelter capacity of 210,000 tons a year as rapidly as conditions permit. Their willingness to participate is based on the conviction that the scheme would be capable of rapid expansion. In the first place, however, a capacity of 80,000 tons a year would be installed. The aluminium companies would be prepared at the request of the two Governments to commit themselves to expand the capacity to 120,000 tons a year within a period of seven years from the date when power first became available unless the two Governments subsequently agreed to extend the period. The aluminium companies would further be prepared at intervals of three years to consult with the two Governments on ways and means of attaining the maximum capacity of 210,000 tons. If a capacity of 210,000 tons had not been reached within twenty years from initial production, they would undertake to examine the position with the two Governments. Failing agreement as to the feasibility of further expansion the power not required for the existing and immediately projected capacity of the smelter could be released to other users.

Administration of the Scheme

Broadly speaking, therefore, the scheme falls into three parts :

(*a*) The construction of a power station at Ajena about 70 miles from the mouth of the Volta River, involving the creation of a reservoir with an area of 2000 square miles. This would ultimately have a continuous generating capacity of 564MW and would, it is provisionally estimated, cost £54,000,000, but the full capacity would not be installed at the outset and it is estimated that the cost of the initial stage would be £45,500,000. Power should begin to become available from five to seven years after work begins. By far the greater part would be used for aluminium production, but power would also be available for other consumers.

(*b*) The erection of an aluminium smelter in the vicinity of Kpong, 12 miles from Ajena. This would have an initial capacity of 80,000 tons and an ultimate capacity of 210,000 tons of aluminium a year ; it would be hoped to attain the full capacity within at most twenty years from opening the smelter. The bauxite deposits at Mpraeso and Yenahin would be developed to supply the smelter. The cost of a plant and ancillary works to produce 80,000 tons a year is estimated to be £29,000,000. The full development, to 210,000 tons annual capacity, is estimated to cost £64,000,000. Aluminium production would begin as soon as the power project was in operation.

(*c*) Extensive public works at an estimated cost of about £26,000,000 would be required. They would include new port facilities, railway and road developments, and housing, schools and other amenities. Of this, some £11,000,000 would be for a new port. The Gold Coast Government have decided that a new port at Tema is required in any case for the general needs of the territory, and preliminary work is already in hand.

The total cost would, therefore, on present estimates be of the order of £100 million for aluminium production at the initial rate of 80,000 tons a year and £144 million at the maximum rate. However, the risk of exceeding the estimates by a substantial margin is not one which can be removed from a scheme of this nature.

The conception behind the scheme is of a partnership in which private enterprise would be primarily responsible for aluminium production and the two Governments for the hydro-electric scheme and the public works and services. The Gold Coast Government would be responsible for financing and carrying out the public works, i.e. port, railways, roads and townships at the dam site and port. The United Kingdom Government would have the major responsibility for financing the power project, but the Gold Coast Government would contribute to the cost as far as their resources permitted. A public authority, the "Volta River Authority," would be created to undertake the construction of the dam and hydro-electric works. On completion the power undertaking would be taken over by an autonomous board, the "Volta Electricity Board." The Authority and the Board would be responsible to the Gold Coast Government, but their chairmen would be appointed jointly by the two Governments. The development and operation of the aluminium smelter and the bauxite mines, together with the new towns at the smelter and mines, would be the responsibility of a company (the "smelter company") the equity in which would be provided by the aluminium companies except for a minority holding in Gold Coast hands. It is, however, proposed that the United Kingdom Government should provide about a fifth of the initial capital and should be prepared, if called upon, also to provide up to half the cost of expanding the capacity from 80,000 to 120,000 tons ; these contributions would be on a suitable non-equity basis.

All the parties are, however, conscious of the difficulties which are inherent in a scheme of this magnitude undertaken under tropical conditions in a territory whose economy is developing rapidly in other directions. It is in particular important to make sure that the large labour force for the power project can be recruited, fed, housed and maintained ; that the port, rail and road developments are carried out according to programme ; that waste and extravagance are avoided, and that the scheme, once launched, is not dislocated because of other claims upon resources. One of the chief tasks of the Volta River Authority would be to synchronise work upon the different aspects of the scheme and to secure the necessary priorities so that it might be completed with maximum efficiency and in accordance with an agreed time-table. The Gold Coast Government have stated that they would be ready, whenever the occasion arose, to defer or rephase other parts of their development programme which seemed likely to conflict with the scheme in the demands on the resources available of men, transport and materials.

Careful preliminary examination has shown no reason for thinking that the difficulties are insuperable, but in the discussions at Accra in June, 1952, it was agreed that there was a good deal more preparatory work to be done before the parties could be expected to commit themselves finally. As recommended in the Accra discussions, the United Kingdom and the Gold Coast Governments propose, therefore, to establish a preparatory commission, under a special commissioner, with the following duties :—

(i) In conjunction with the Gold Coast Government to determine the phasing of the project with other Gold Coast Government development projects in the light of the available resources of the Gold Coast economy, including the adequacy of the Government services.

(ii) To take part in the determination of the constitution and powers of the Volta River Authority.

(iii) To continue the development of the necessary preparatory work with the assistance of such staff as the aluminium companies can make available.

(iv) To take part in the preparation of a master agreement.

The preparatory commission will be appointed as soon as possible and will be instructed to proceed with its work with all practicable speed.

French Engineering News

(By Our French Correspondent)

Electricité de France has devised a new method for financing development. It comprises a loan based on production and the electricity tariff. The public is invited to buy shares valued at 16,000 francs. Interest on them is based on the cost of production and the sale price of electricity. Each share earns in interest the price of 100kWh per year. As there are several tariffs, a mean has been struck. The interest paid on one share this year is 720 francs; if next year or in any following year, the price of electricity rises, then the interest in the shares would rise. Further, the increase would be reflected in the capital price of the shares which would increase as well.

One interesting point is that the Electricité de France does not expect a reduction in the price of electricity. Although the capital obtained in this way will be used to develop both hydro-electric and thermal power, and production will rise steeply, the price will certainly not come down, it is thought, as the cost of building is so high.

Almost every month now the E.d.F. breaks its own record for production. The reservoirs are full and on November 5th, production reached the peak of 79·3 million kWh from hydro-electric and 44 million kWh from thermal power stations.

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It has now been decided that construction of the Mont-Blanc tunnel will start early in 1953. At present the engineers concerned do not believe that they will encounter any unusually difficult problems. The following dimensions have been agreed : width of the roadway 6m ; height of the tunnel 4·35m. The tunnel will be almost 13 km long. The work is expected to last about three years.

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Electricity production in Algeria, which was 330 million kWh in 1945, has increased to 730 million. This has been achieved by the completion of an important constructional programme, started in 1948, which included the harnessing of the oued Agrioun in the Kerrata area, with the construction of a high dam and a reservoir with a capacity of 168 million cubic metres. A hydro-electric power station of 24MW is installed at the foot of the dam. A smaller dam diverts the water to an 8 km tunnel, with a capacity of 20 cumecs. Penstocks at the end of the tunnel carry the water 370m down to the principal power station, which is built 60m underground. The machine hall is 70m long, 20m wide and 22m high, and two 33MW sets are installed. The transformers are on the surface. Production is about 185 million kWh per year.

Electricity production is expected to reach 1000 million kWh in 1956. The Djendjen hydro-electric scheme, with a capacity of 125MW, with the possibility of developing to 175MW, and an annual production of about 310 million kWh, will then be in service. Other developments which it is hoped to have under construction by 1956 include a 100MW thermal power station at Algiers.

* * *

The Houilleres du Nord et du Pas de Calais proposes to build a large power station for its own use, which will be constructed in four stages of 100,000kW and will eventually have a capacity of 400,000kW. The new plant will sell the greater part of its output to Electricité de France. A 45kV network will be built to distribute a part of the power produced among the mines in the area. The plant will take several years to complete and eventually will replace a number of smaller installations. The area will eventually be served completely by the new power plant (at La Bassée), and seven smaller plants of 100,000kW installed at Thiers, Dechy, Harnes, Beuvry, Chocques, and Labuissiere, on which work is well advanced.

* * *

The first turbo-diesel locomotive constructed by Renault is to be placed in service on Northern network. This 1000 h.p. locomotive is 16m long and weighs 58 tons. It is a gas turbine locomotive, stated to be the first of its kind in the world, and it took Renault two years to design and build.

Industrial and Labour Notes

Iron and Steel Production

Steel production in Great Britain in November was at the highest annual rate ever recorded in this country. The average weekly output of ingots and castings was 345,200 tons, which represented an annual production rate of 17,951,000 tons, compared with an annual rate of 17,044,000 tons in October, and a rate of 16,437,000 tons in November last year. Taking the first eleven months of this year, steel production has been at an annual rate of 16,087,000 tons, compared with 15,696,000 tons in the corresponding period of 1951. Pig iron output during November averaged 206,800 tons a week, representing an annual production rate of 10,753,000 tons, compared with a rate of 10,194,000 tons in November last year. In the first eleven months of the year, the annual rate of pig iron production was 10,504,000 tons, compared with 9,618,000 tons in the corresponding months of last year. In publishing these figures, the British Iron and Steel Federation says that the last record steel production was in November, 1950, when an annual output rate of 17,472,000 tons was achieved.

Employment and Unemployment

The Ministry of Labour's report on the employment situation in Great Britain says that during the month of October there was little change in the size of the total working population. At the end of the month it totalled 23,391,000 (16,017,000 men and 7,374,000 women). An increase of 1000 in the number of women at work was offset by a decrease of 1000 in the number of men, so that the total was the same as that recorded at the end of September. The size of H.M. Forces remained at 873,000 during October, but there was a decrease of 29,000 in the number of people in civil employment, the total at the end of October being 22,146,000 (14,938,000 men and 7,208,000 women).

The number of people working in the basic industries during October was 4,111,000, which was 44,000 fewer than at the end of September. Most of this decline occurred in agriculture and can therefore be regarded as seasonal. At the same time, there was a drop of 1000 during October in the number of wage earners on colliery books, the end-of-the-month total being 719,000. The labour forces in the manufacturing industries of the country, however, increased during October, and at the end of the month totalled 8,630,000, compared with 8,599,000 at the end of September. There was considerable improvement in the textile industries in October. In the manufacturing industries classified as "engineering, metal goods and precision instruments" and "vehicles," there were additions to the labour forces of 1000 in each case, the end-of-the-month totals being 2,564,000 and 1,090,000 respectively. The only decline—of 1000—was in chemicals manufacture. In other industries and services there was a drop of 10,000 in the number employed in building and contracting, and a decrease of 11,000 in the number engaged in "professional, financial and miscellaneous services."

Figures for unemployment which are included in the Ministry's report relate to November 10th, when 406,366 people were registered as out of work, compared with 397,893 on October 13th. The Ministry says that the November figure represents about 2 per cent of the total number of employees as against 1·9 per cent on October 13th. The November total of unemployed includes 36,216 described as "temporarily stopped."

O.E.E.C. Reports on Steel and Non-Ferrous Metals

The Organisation for European Economic Co-operation has recently stated that steel output in its member-countries increased from 51,000,000 tons in 1950 to 56,600,000 tons in 1951, but it says that the increase could have been about 1,500,000 tons greater had the necessary raw materials been available. For the same reason, the O.E.E.C. suggests, the total steel output for 1952 may be 2,000,000 to 3,000,000 tons short of the production capacity available. It estimates that if maximum production is to be attained this year, 41,100,000 tons of scrap and 50,800,000 tons of pig iron are necessary. This, however, would mean an increase of scrap imports from non-member countries from 1,100,000 tons in 1951 to 2,800,000 tons this year, an achievement which has not been possible. About pig iron, the O.E.E.C. says that, on its original estimates for the current year, lack of raw materials will have resulted in production falling short of the target by about 2,000,000 tons. In the earlier part of the year efforts were made by ore producers to increase their output, a trend which has continued. It is thought that, with better supplies of iron ore, combined with better supplies of coke, a total steel production of between 61,000,000 and 61,500,000 tons may perhaps be reached.

The O.E.E.C. has also reported on the non-ferrous metals situation, noting that the supply position for aluminium, copper, lead and zinc has improved considerably over the last six months. Only in the case of nickel does an acute shortage continue to exist. Compared with the same period of 1951, aluminium during the first six months of this year reached a record figure of 197,200 tons, an increase of about 17 per cent. For lead, the metal production remained stable, while mining production rose about 16 per cent, and in the case of zinc, metal production fell by 4 per cent, but mining production increased by approximately 11 per cent. The report comments that, in the free world, as a whole, the sellers' market for lead and zinc has changed into a buyers' market, and for the other metals the balance has been more or less maintained between production and consumption. The one exception is nickel, where, of course, the continued shortage is attributable mainly to the heavy requirements of defence programmes.

Private Trading in Zinc

The Ministry of Materials has already announced that dealings in zinc are to be resumed on the London Metal Exchange on January 2nd next. This week the Board of Trade has made a statement outlining import and export licensing arrangements. This statement says that, for the import of zinc spelter unwrought in ingots, blocks, bars, slabs and cakes—but not including alloys of zinc—members of the London Metal Exchange who participate in the Bank of England exchange control scheme will be granted open individual licences valid for importing from any source. Consumers who wish regularly to import substantial quantities of zinc otherwise than through the Exchange will be granted open individual licences valid for appropriate sources of supply. Applicants should state the quantities they expect to import in the ensuing twelve months and the main sources from which they expect to purchase. Such open licences will be granted on condition that returns showing full details of both value and source of imports are made to the Board of Trade at monthly intervals. Other traders wishing to import zinc must make application for a licence in respect of each individual transaction. All applications for licences should be sent to the Board of Trade, Import Licensing Branch, Romney House, Tufton Street, London, S.W.1.

As from January 1st, there will be a resumption of exports of unwrought zinc in ingot form. Traders wishing to export unwrought zinc should make application to the Board of Trade, Export Licensing Branch, Atlantic House, Holborn Viaduct, London, E.C.1. The Board says that licences will not normally be granted for the export of unwrought zinc other than virgin zinc in ingot form. The arrangements include no change in the regulations governing the export of old metal and scrap.

The Transport Bill

On Friday last, the Minister of Transport, Mr. Alan Lennox-Boyd, met representatives of the Trades Union Congress and the unions associated with rail and road transport to discuss various aspects of the Transport Bill. A statement issued after the meeting by the Ministry of Transport said that, while the union representatives made it clear that they were entirely opposed to the main principle of returning long-distance road haulage to private enterprise, there was a useful discussion on specific issues directly affecting trade union members.

Among the matters discussed with the Minister were the provisions of the Transport Bill affecting the pension rights of employees, and compensation to employees; the implications of the Bill as to employment, wages and conditions of service in road transport, the negotiating machinery in the Commission's undertaking as affected by the main provisions of the Bill, and the size of the road haulage fleet to be retained under the control of the British Transport Commission. During the discussions, the Minister formally asked the T.U.C. representatives to consider nominating a trade union member to the proposed Disposals Board should Parliament decide to amend the Bill in that sense. The T.U.C. representatives undertook to consider the request.

Residential Work Study School

The British Institute of Management has announced the setting up, at the College of Aeronautics, Cranfield, of the first residential school to provide a course for the training of work study officers capable of undertaking immediate investigations. There are to be three courses annually of ten weeks' duration and the fee will be 200 guineas inclusive. In the first instance, the courses will be limited to twenty students and special consideration will be given to small firms wishing to send personnel. The first course will be held from January 12 to March 20, 1953, and applications for it should be made at once. Suitable applicants for whom there is no room at the first course will be accepted for later courses.

The British Institute of Management says that work study is generally agreed to be one of the most rapid and effective ways of increasing the output and productivity of British industry, but, in spite of the importance attached to it, the facilities for training and research have been confined until now to short courses run by a few colleges of technology, by certain large-scale industrial organisations for their own staffs and by consultants for their clients. It adds that in Germany and France there have been for some time central organisations for the training of work study personnel serving industry as a whole. It is therefore suggested that the absence of such an organisation in this country has seriously handicapped the application of work study in industry. The school which has now been established is intended to provide for industry as a whole a central school at which there will be given a thorough grounding in the theory and practice of work study, suitable for those executives who are to be responsible for its introduction and development within their own firms. It is hoped also to arrange short courses on various specific aspects for practitioners and teachers of work study. Furthermore, it is intended that the school shall be the centre for conducting and co-ordinating research and public activities in the field of work study.

The syllabus is to include the latest practices in such techniques as method study, work measurement, incentive schemes, and job evaluation and general background subjects such as labour relations, statistical methods, and report preparation and presentation. In addition to the lectures and practical training within the school itself, visits will be arranged during the courses to factories where work study is practised.

Notes and Memoranda

Rail and Road

AN HISTORIC VILLIERS ENGINE.—One of the first Villiers four-stroke engine gear units, made forty years ago, has been found in Australia. Although Villiers Engineering Company, Ltd., eventually dropped four-strokes in favour of its two-stroke series, these early engines with a bore and stroke of 74mm by 80mm and a capacity of 349 c.c. had quite a number of details which were revolutionary in their day. Aluminium castings were extensively used, and there was a two-speed gearbox, enclosed primary drive chain and cone clutch built-in unit with the engine, and a kickstarter in place of the "run-and-jump" method used at the time. The overhead inlet valve was operated by an external pushrod and rocker arm, while the exhaust valve was of the side type. These engines consequently met with a lot of prejudice from the infant motor cycle industry of the day. As with most other British engines at this time, magnetos of German make were fitted, and on this model the magneto was driven from the crankshaft (again similarly to modern practice) by a train of no less than five gears. The Villiers design was to combine the magneto with the flywheel.

THE ROAD FUND REPORT.—The "Report on the Administration of the Road Fund for 1951–52," which has been published by H.M. Stationery Office (price 2s. 6d.), states that payments from the Road Fund towards expenditure on the maintenance and minor improvement of trunk and classified roads during the year ended last March were increased by £4,500,000. Payments for trunk roads totalled over £10,000,000, of which total over £8,000,000 was for maintenance and minor improvements, an increase of nearly £1,800,000 compared with 1950–51. Grants to highway authorities totalled £17,628,000, compared with £15,825,000 in 1950–51. Of this total, £15,496,000 was for maintenance and minor improvement work, and £1,548,000 for major improvement, new construction, &c. The corresponding figures for 1950–51 were £12,849,000 and £2,400,000. The average expenditure per mile on maintenance, repair and minor improvement of roads other than trunk roads throughout the country in 1950–51 was £248. The report says that during the year the Minister of Transport authorised ninety-six new schemes of major improvement of trunk roads, estimated to cost £592,064, and the preparation at a cost of £152,702, including land acquisition, of forty schemes for future improvements. Preliminary survey and road location work to fix the future lines of trunk roads was continued. About 800 miles of the trunk road system were surveyed in detail from the air or on the ground. Further progress was also made with the work of preparing special road schemes under the Special Roads Act, 1949.

Air and Water

NEW PROBLEMS IN THE AIR.—In our leading article under this heading last week an erroneous figure was quoted of the passenger-miles flown by British Overseas Airways Corporation during the four-year period July, 1948, to June, 1952. We gave the figure as 2,000,000 passenger-miles, very obviously much too low. The accurate figure for the period named is, of course, more than a thousand times larger at 2,518,646,000. We regret the error.

A HINGED SWEPT-WING AIRCRAFT.—Another British research aircraft, the "SB/5," made its first flight last week. This machine was designed and manufactured for the Ministry of Supply by Short Brothers and Harland, Ltd., Belfast. The aircraft is to be used for investigations into the low-speed characteristics of swept-back wings. It has an extremely thin wing and is the first machine in this country on which the wing is hinged to enable variable angles of sweep back to be adopted. In the extreme case the sweep of the chord line is 50 deg.

FIRE SERVICES AT AIRPORTS.—The Minister of Civil Aviation, Mr. A. T. Lennox-Boyd, has decided to reorganise and re-equip the Ministry's fire service as a result of a thorough review of the present fire-fighting arrangements. More modern fire tenders and additional fast rescue vehicles will be provided; there will also be a greater standardisation of equipment. The first few minutes of an outbreak of fire in an aircraft are particularly vital and speed and flexibility are the first requirements of an efficient fire-fighting organisation. The purpose of these changes, therefore, is to increase the speed of rescue from crashed aircraft by a smaller fleet of faster and more up-to-date vehicles, manned by fewer men. The rate of application of foam to a fire in the first few crucial minutes will nowhere be decreased and in many cases substantially increased. The Minister also considers that this progressive reorganisation will achieve greater economy by eliminating obsolescent vehicles and saving some staff.

UNIVERSAL FUEL GOVERNOR.—A universal fuel governor claimed to be the first to make possible the use of all forms of liquid fuel in turbo-jet and turbo-propeller engines has been developed by Dowty Equipment, Ltd. It overcomes the deficiency in overspeed governors of the hydraulic principle in current use, which can only be set to operate with one fuel. So many kinds of fuel are now used that there is a large variation in their density, which if not compensated, can result in the engine speed varying significantly above or below the designed figure. The company had first to establish that a relationship exists between the viscosities and densities of these fuels. Compensating devices which utilise this principle are incorporated in the universal fuel governor. The arrangement consists of a metering system having a constant pressure drop, capable of metering a quantity of fuel as a function of viscosity, so that low density fuels flow in greater volume than those of high density, or vice versa, thus providing the necessary compensation at the designed engine speed.

P. AND O. LINER "RANCHI."—The P. and O. liner "Ranchi" is making her last voyage to Australia and will be broken up after her arrival in London on January 1, 1953. The ship, one of four sisters, was built by R. and W. Hawthorn Leslie and Co., Ltd., in 1925, and was the only one of the four to return to the company after the war, the "Rawalpindi" and "Rajputana" being sunk and the "Ranpura" being retained by the Navy.

Miscellanea

OLDHAM DEVELOPMENT PLAN.—The Minister o Housing and Local Government has approved with modifications the development plan for the County Borough of Oldham.

CENSUS OF PRODUCTION, 1948.—Among the series of final reports on the Census of Production, 1948, which have just been published by H.M. Stationery Office, are "Chain, Nail, Screw and Miscellaneous Forgings" (price 3s. 6d.), and "Gas Supply Industry" (Volume 12, trade F) (price 3s.).

RADIOACTIVE SUBSTANCES ADVISORY COMMITTEE.—Sir Charles Darwin, K.B.E., D.Sc., F.R.S., has been appointed chairman of the Radioactive Substances Advisory Committee in succession to Sir Henry Dale, O.M., G.B.E., F.R.S., who has resigned. Professor G. R. Cameron, F.R.S., and Professor K. G. Emeleus, M.A., Ph.D., have been appointed to the committee.

SEAWEED UTILISATION SOCIETY.—As a result of a recent meeting of ex-members of the late Scottish Seaweed Research Association, it has been decided to form a society to be known as the Seaweed Utilisation Society. Its object will be to serve as a two-way channel of information and opinion between the Institute of Seaweed Research and the Society. The secretary of the new society is Miss M. D. Walker, 49, Rodney Street, Liverpool, 1.

SULPHUR AND SULPHURIC ACID.—In a recent written reply, the Minister of Materials, Sir A. Salter, says that encouragement has been given to the erection of plant to produce sulphuric acid from pyrites and native anhydrite instead of sulphur. By the end of this year new capacity of this kind to produce 227,000 tons of acid annually will be working, and another 460,000 tons in 1953. A plant for recovering an additional 17,000 tons of by-product sulphur a year will be working this year, and another 12,000 tons in 1953.

THIRD INTERNATIONAL CONFERENCE ON SOIL MECHANICS.—The executive committee of the International Society of Soil Mechanics and Foundation Engineering has arranged for the third international conference on soil mechanics to be held in Switzerland next August. The first part of the congress will be held in Zurich from August 16 to 21, 1953, during which most of the official business of the congress will take place and papers will be presented for discussion. The second part of the congress from August 22nd to 25th includes a four days' tour through Switzerland, to give members an opportunity of visiting places of particular interest for geotechnical and foundation engineering, as well as seeing something of the country itself. The final session of the congress will be at Lausanne on August 26th.

CONFERENCE ON STATIC ELECTRIFICATION.—The Institute of Physics has arranged a conference on static electrification, to be held at Bedford College, London, on March 25 to 27, 1953. The opening lecture will be by Professor F. A. Vick, O.B.E., F.Inst.P., of the University College of North Staffordshire, Stoke-on-Trent, and the other sessions will each take the form of an introductory survey, followed by specialised papers and discussion. The introductory surveys will be given by Dr. P. S. Henry, F.Inst.P. ("General Principles of the Generation and Dissipation of Static Electricity"), Dr. E. S. Shire ("Electrostatic Machines"), and Mr. H. W. Swann, O.B.E. ("Harmful Static Electrification"). Further particulars can be obtained from the Conference Secretary, Mr. N. Clarke, F.Inst.P., the Institute of Physics, 47, Belgrave Square, London, S.W.1.

ROYAL SOCIETY OF ARTS.—We are happy to have received from the Royal Society of Arts a copy of the centenary issue of its *Journal*, which is dated "Friday, 28 November 1952." The first issue appeared on Friday, November 26, 1852. This centenary number appropriately includes many extracts from papers and articles published in the *Journal* during the first hundred years of its career. Among the earlier contributions which have been thus recalled there may be mentioned a note, published in 1853, on "Communication Between the Guard and Driver of a Railway Train"; a paper, presented in 1856 by George Wallis, entitled "Recent Progress in Design"; and a paper, dated 1894, on "Experiments in Aeronautics," which was presented by Hiram S. Maxim. This special issue includes also the full text of the interesting lecture entitled "The Centenary of the Society's Journal," which was delivered on November 5th by Mr. E. Munro Runtz, chairman of the Council.

AN IMPROVED ELEVATOR BUCKET.—A new leaflet, issued by Foundry Equipment, Ltd., Linslade Works, Leighton Buzzard, Beds, described an improved bucket which can be used on all designs of elevators. The new self-cleaning, stripper bucket, as it is described, consists of a pressed steel bucket in the body of which is a hinged stripper plate. When the bucket is in the elevating position the stripper plate forms a close-fitting bottom. As the bucket passes over the elevator head pulley to the dumping position the hinged stripper plate flies over to eject the contents of the bucket cleanly into the elevator chute. At the end of its ejection movement the plate raps the bucket, and this rap ensures complete removal of all material adhering to the inside and outside of the bucket. At present four standard sizes of bucket—for 9in, 12in, 16in and 20in wide belts—are being made, but the makers inform us that non-standard sizes for chain or belt mounting can be supplied.

BARNSTAPLE TRANSMITTING STATION.—Yesterday, December 11th, the new permanent transmitting station at Fremington, between Barnstaple and Bideford, took over the B.B.C. West of England Home Service on 285m (1052kc/s) from the temporary transmitter which has been operating from a caravan on the site. This is one of a number of low-power stations being built by the B.B.C. to improve reception of the Home Services in certain areas. The new transmitter is of higher power than the caravan transmitter and extends the coverage beyond the immediate surroundings of Barnstaple and Bideford to include the outlying districts such as Northam and Great Torrington. The equipment, which is housed in a building some 14ft square, is designed for completely automatic operation without the attendance of staff. It comprises two Marconi transmitters working in parallel to give an output of 1½kW; they are switched on and off automatically by a time switch. Later, a third transmitter unit will be added to increase the power to 2kW. The station receives its programme over Post Office lines from Bristol and the incoming and radiated programme is checked by automatic monitoring equipment designed and developed by B.B.C. engineers. Should a fault develop in one of the transmitter sections the faulty section is automatically disconnected and the service continued on reduced power.

Personal and Business

MR. R. A. HARDING, general manager of Macrome, Ltd., Aldersley, Wolverhampton, has been appointed a director of the company.

SOUTHERN FORGE, Ltd., Langley, Bucks, states that Mr. L. E. Young, sales manager, has been appointed a director of the company.

MR. F. MOORES, A.M.I.E.E., has been appointed manager of the capacitor department of Johnson and Phillips, Ltd., Charlton, S.E.7.

ELLIOTT BROTHERS (LONDON), Ltd., states that its Birmingham branch has been moved to 181, Corporation Street, Birmingham, 4 (telephone, Central 8313).

THE FINLAY CONVEYOR COMPANY, Ltd., Transporter Bridge, Newport, Mon, announces that, as from January 1st next its title will be Finlay Engineering, Ltd.

GARRINGTONS, Ltd., Bromsgrove, states that Mr. G. F. Brown, secretary, has been appointed a director, and that Mr. B. E. J. Hodson, general works manager, has been appointed works director.

MR. S. A. SCADDING has resigned his appointment as assistant sales manager and publicity officer of J. and H. McLaren, Ltd., Leeds, to become general manager of the Northern General Supplies Company, Ltd., Leeds.

DIXON HAWKESWORTH, Ltd., Middleton, Lancs, announces that its concrete mixers, sludge pumps and other equipment are now distributed in the United Kingdom and Eire by Buckton, Ltd., Ashton-under-Lyne.

A. C. MORRISON (ENGINEERS), Ltd., Loughborough, announces the following agency appointments:—Israel, Mr. Joseph Muller, P.O. Box 243, Haifa; N.W. India and Assam, Sardar Uttam Singh Dugal and Co., Ltd., 11, Marina Arcade, New Delhi.

THE P. AND O. STEAM NAVIGATION COMPANY announces that Captain H. S. Allan, R.D., R.N.R., who has been commodore of the fleet since 1951, has reached retiring age and has made his last voyage in the "Strathaird," which he has commanded since 1947.

SILENTBLOC, Ltd., states that Mr. Ian M. Gillett, general manager, has been appointed managing director, and that Mr. Brian H. Dulanty has been appointed to the board. Mr. S. Buchan, general manager of the Andre Rubber Company, Ltd. (a subsidiary of Silentbloc, Ltd.) has been appointed a director of that company.

MR. H. COPPING, M.I.E.E., who recently resigned from the position of general home sales manager of Newman Industries, Ltd., sailed for Toronto on December 10th. Mr. Copping is now associated with Electric Construction Company, Ltd., Wolverhampton, and British Overseas Engineering and Construction Corporation, Ltd., Eccleston Street, London, S.W.1.

WILLIAM DENNY AND BROTHERS, Ltd., announces that Sir Maurice Denny, Bart., will retire from the chairmanship of the company at the end of the year and will be succeeded by Mr. Edward L. Denny. Other changes will be the retirement of Mr. John M. Denny and Mr. William Denny as directors. The board intends to invite Sir Maurice Denny to become president of the company from January 1, 1953.

British Patent Specifications

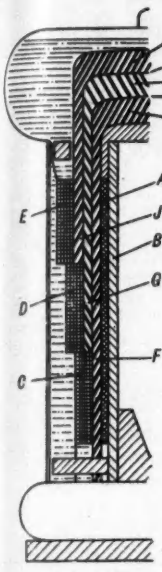
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

ELECTRICAL ENGINEERING

682,257. December 23, 1949.—HIGH-VOLTAGE TRANSFORMERS, The English Electric Company, Ltd., Queens House, 28, Kingsway, London, W.C.2. (*Inventor: George Fletcher Stearn.*)

The invention relates to high-voltage transformers, such as testing transformers having an incomplete ferro-magnetic circuit. In such transformers the current needed to magnetise the core tends to be unduly large. The object of the invention is to reduce the effective magnetising current in such a transformer. As the drawing shows, a low-voltage winding *A* is wound in a number of parallel windings stretching the length of a radial core *B* with an incomplete magnetic circuit. High-voltage windings are wound in three stacks *C*, *D* and *E*. Between the bottom stack *C* and the low-voltage winding *A* is a column of radial insulation *F*. A column of radial insulation *G* is equal in depth to and disposed about the column of radial insulation *F*. Between these two columns of radial insulation is an electrically conductive potential shield *H*, which is connected to the junction of the bottom stack *C* and the middle stack *D*. A column of radial insulation *J* is equal in depth to the column of radial insulation *F* and is disposed about the column of radial insulation *G*. Between the two columns of radial insulation is an electrically conductive potential shield *K*, which is joined to the junction of the middle stack *D* and the top stack *E*.—*November* 5, 1952.



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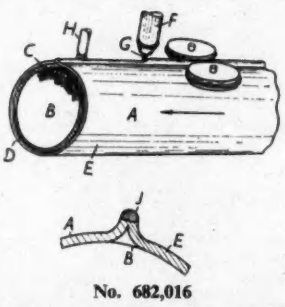
682,016. April 4, 1950.—ELECTRIC CABLES, The General Electric Company, Ltd., of Magnet House, Kingsway, London, W.C.2, and James Arthur Donelan and James Ronald Penrose, both of Research Laboratories of The General Electric Company, Ltd., Wembley, Middlesex.

An object of the invention is the provision of an improved construction of sheathed electric cable. Referring to the drawing, the sheathed cable *A* consists of a single core *B* with a number of paper-insulated conductors *C* surrounded by several paper layers *D* and a stabilised, stainless steel sheath *E*.



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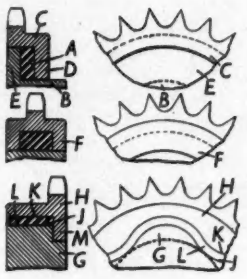
The cable is made by bending strip steel round the core and welding the seam by a water-cooled argon shielded arc machine torch *F*, the seam being run in the direction of the arrow under the torch electrode *G*, which is stationary. The circular cable core is about $\frac{1}{4}$in in diameter, is enclosed in the steel sheath *E* made of 21 gauge strip material and two radial flanges, each about $\frac{1}{32}$in high, are provided. When under the welding torch the flanges may be pressed together by suitable rollers. The electric supply for the torch is d.c., the sheath being positive and the welding electrode negative, and the seam is run under the torch at a speed of about 9ft per minute. No flux is used and at this speed with an arc gap between the electrode and the free tips of the flanges of about 0·04in to 0·06in, a welding current of about 120A is used. To prevent the heat of welding damaging the cable core, a water quench *K* may be used. As will be seen from the lower view, the metal of the flanges under the welding arc runs into a nicely rounded bead *J* and the weld is of a much better shape than that produced by resistance welding where there is no flow of metal.—*November* 5, 1952.

POWER TRANSMISSION

682,196. December 23, 1949.—CHAIN WHEELS OR SPROCKETS, The Renold and Coventry Chain Company, Ltd., Renold Works, Didsbury, Manchester. (*Inventor: Onissim Burawoy, of the company's address.*)

As shown in the upper drawing, a narrow rubber ring *A* is bonded to concentric cylindrical surfaces on the hub *B* and rim *C*. The rim has a flange *D* which covers one face of the ring and extends into contact with the hub. The hub has a similar flange *E* extending into contact with the rim, so that relative radial displacement of the hub and rim is prevented. In the construction shown in the centre view, both



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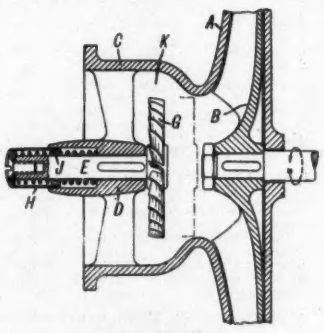
flanges are formed on the rim, as shown at *F*. The lower view shows a construction in which the hub *G* and rim *H* have wavy opposed surfaces *J* and *K*, to which is bonded a rubber ring *L*. Relative radial displacement of the hub and rim is prevented by a single deep flange *M*. The flexible parts serve to reduce irregularity in the load transmitted by the chain and so to prolong the life of the chain and of the teeth over which it runs. Fluctuations in speed and load on one shaft are attenuated before they reach the other shafts. In addition, the flexible parts damp out vibrations and confine them to the part of an apparatus in which they originate.—*November* 5, 1952.

INTERNAL COMBUSTION ENGINES

682,654. February 12, 1951.—REGULATION OF CHARGING BLOWERS FOR INTERNAL COMBUSTION ENGINES, Daimler-Benz Aktiengesellschaft, Stuttgart-Unterturkheim, Germany.

The drawing shows a section through the entry side of a charging blower for an internal combustion engine for driving a motor vehicle. The charging blower, designed as a radial flow compressor, consists of a housing *A* and an impeller *B*, which is driven, at comparatively high speed in the direction of the arrow. The speed of the blower is so chosen that it produces the full charging pressure when the engine shaft has attained approximately two-thirds of its maximum operating speed. Upon further increase of the driving speed, throttling of the charging air is necessary and this is performed automatically and with comparatively slight loss of energy. The suction connection *C* of the blower is conically tapered towards the impeller. At the



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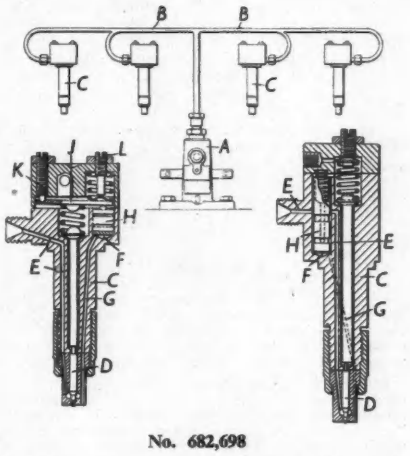
outer end of the connection a support *D* carries an axially displaceable non-rotatable pin *E*. The hub of a twist diaphragm with fixed rigid blades *G* is fixed upon the inner end of the pin. A sleeve *H*, against whose base a helical spring abuts, is secured to the outer end of the pin. The other end of this spring bears against a ring *J* which slides in the sleeve and on the pin. A second, stronger, spring is arranged between this ring and a shoulder in the bore of the support. Under the action of the two springs the diaphragm *G* assumes the position of rest, illustrated in the drawing, in which it is situated in the widest cross section of the tapered part of the suction connection. The initial stress in the springs is so designed that the diaphragm remains in this rest position until the blower, with increasing speed, has attained the full charging pressure. Up to this point the air drawn in by the blower finds its way largely through the annular gap *K* around the diaphragm, no considerable twist being yet imposed upon the air. Upon further increase of the blower speed the diaphragm is drawn, against the action of the springs, into the tapered part by the increasing suction in the connection until it assumes the position indicated by dotted lines at the maximum operating speed. Due to the resultant constriction at the free annular cross section, the air drawn in must now find its way to an increasing extent through the diaphragm itself, in which a rotary motion is imparted to the air. The quantity of air drawn in is thus throttled, but with little loss of energy. Upon the advance of the diaphragm from the rest position to the innermost position, first of all the outer, weaker spring is compressed and only then the stronger, inner spring. With this arrangement the spring means has an interrupted characteristic which rises more steeply in the later part of the deflection. Other spring means can be used, but it must in any case be so designed that, at every speed in the excess-speed range of the blower, it yields to the increasing suction exerted upon the diaphragm to such an extent only as is necessary for attaining the most favourable throttling or twist effect at that speed.—*November* 12, 1952.

682,698. February 6, 1950.—FUEL INJECTION SYSTEMS FOR COMPRESSION-IGNITION ENGINES, Bryce Fuel Injection, Ltd., Ironbarks Works, The Causeway, Staines, Middlesex, Donald Runciman Johnson and Geoffrey Ralph Green, both of the company's address.

The invention provides a fuel injection system employing a single metering pump for feeding a group of injectors and in which the sequence of injection into the respective cylinders is determined by the pressure prevailing in the cylinders. The use of mechanically driven distributing arrangements is avoided and the accuracy of timing remains



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unaffected during the working life of the engine. In the system illustrated by the drawings, the metering elements consist of a single unit pump *A* in which metering is performed. The pump supplies fuel to a high-pressure line *B* feeding all the injectors *C* via the branches. As the left view shows, the body of each injector *C* is equipped with a needle valve *D* loaded by a spring and the fuel is admitted to a conduit *E* in the injector body. This has also a chamber *F* in permanent communication with the combustion chamber of the engine cylinder to which the injector is fitted by means of a conduit *G*. The chamber contains a pressure responsive device in the form of a piston or diaphragm *H* loaded by a spring. A lever *J* forming an abutment for the usual loading spring of the needle valve is fulcrumed at one end on the tip of an adjustable screw *K* and bears at its other end on the piston or diaphragm *H*, the travel of which is restricted by an adjustable screw *L*. With this arrangement the engine cylinder pressure during the compression stroke, transmitted via the conduit *G*, will move the piston *H* and the lever *J* to reduce the spring load exerted on the needle valve *D* so that it opens and fuel is injected. As only one cylinder is under compression at one time it follows that a suitably timed delivery of fuel from the fuel pump *A* will operate only the injector in communication with that particular cylinder. In the form of the injector shown in the right-hand view the piston or diaphragm *H* is made to serve as a

valve controlling the fuel supply from the pump to the injector. The valve closes the fuel admission conduit *E* until the cylinder pressure (which is transmitted via the conduit *G* to the valve chamber *F*) rises sufficiently on each compression stroke to move the valve and open the conduit by means of the reduced valve portion, whereupon the fuel delivered to the line by the pump is admitted to that particular cylinder.—*November* 12, 1952.

Technical Reports

Industrial Applications of Wind Tunnel Research : Notes on Applied Science, No. 2. London : Department of Scientific and Industrial Research, H.M.S.O. Price 3s. 6d.—The National Physical Laboratory has been concerned with the investigation of the theory and practice of flight since 1918, during which time wind tunnel research has laid down principles of aerodynamics that can also be used to solve industrial problems. These principles are described in the " Notes on Applied Science, No. 2."

The principles apply to any stream of air, which is why there is a connection between aeroplanes in flight and problems such as the oscillations of a suspension bridge in the wind. Aerodynamic research has proved its value in such varied fields as wind pressure on buildings, the reduction of wind resistance on cars and trains, forced and natural ventilation and drying processes.

A good deal of the work has been done on models in wind tunnels. Experiments on some models of cars, for example, showed that there was a tendency for the front wheels to lift at high speeds. The car designs were modified. Another series of experiments was done on a model of the Rock of Gibraltar. The Laboratory was asked to discover why so many aircraft were crashing on flights over the Rock. It was thought that downward moving streams of air might be the cause, and a small-scale model was tested in winds of different speeds and direction. As a check, balloons were sent up on the Rock itself, and the results obtained agreed very closely with the experimental ones. The tests showed that persistent vortices were created by winds. They also showed what precautions should be taken by aircraft flying over Gibraltar according to the weather at the time.

Other experiments have been done to find the best design of ships' funnels to keep decks free of smoke. Methods of raising smoke plumes from power stations and other buildings to keep the surrounding area clear have been developed. The N.P.L. was consulted on the possible smoke nuisance from the Bankside power station opposite St. Paul's, and it has also advised on smoking chimneys at Buckingham Palace.

The report also contains a section on the design of ducts to ensure a steady flow of air, especially round corners. It also describes in detail the design of wind tunnels and the techniques of measurement used with them.

Contracts

C. M. HILL AND CO. (ENGINEERS), Ltd., 44–45, Tower Hill, London, E.C.3, has received on behalf of its principals, S.A. Anglo-Franco-Belge, an order from the Government of India for eighty steam locomotives and tenders, 2–8–2, Class " W.G.," 5ft 6in gauge.

BIRLEC LIMITED, of Erdington, Birmingham, has been commissioned by Samuel Fox and Co., Ltd., in association with the United Steel Companies, Ltd., to supply a " Lectromelt " arc furnace equipment, which will have a nominal capacity of 60 tons and will be rated at 15,000kVA with on-load tap-change gear. Samuel Fox will install this unit at its Stocksbridge Works, where it will be used for the production of high-quality alloy steel ingots. It is said to be the largest ore melting furnace to be manufactured or installed in Great Britain.

Launches and Trial Trips

SIBELLA, oil tanker ; built by the Furness Shipbuilding Company, Ltd., for Skibsaktieselskabet Avanti, Norway ; length between perpendiculars 560ft, breadth moulded 80ft, depth moulded 42ft 3in, deadweight 24,600 tons on 32ft 3½in summer draught ; twenty-seven oil cargo tanks, two pump rooms, four 400 tons per hour Duplex steam pumps, two stripping pumps, one 150kW steam-driven generator, two 250kW diesel generators ; N.E.M. Doxford single-acting, two-stroke, opposed-piston oil engine, six cylinders 670mm diameter by 2320mm combined stroke, 6800 b.h.p. at 116 r.p.m., two Scotch boilers. Trial, November 19th.

RAEBURN, cargo vessel ; built by Harland and Wolff, Ltd., Belfast, for the Lamport and Holt Line, Ltd.; length between perpendiculars 435ft, breadth moulded 63ft, depth to shelter deck 39ft 6in, gross tonnage 8311 ; two steel decks, seven watertight bulkheads, five cargo holds, derrick complement includes one 50-ton and one 30-ton derricks, electrical deck machinery, three 200kW diesel generators ; Harland-B. and W. two-cycle, single-acting, opposed-piston diesel engine, seven cylinders, 750mm diameter by 2000mm combined stroke, 112 r.p.m. Trial, November 28th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on or before the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Dec. 12th.—CREWE BRANCH : Copeland Arms Hotel, Glebe Street, Stoke, Visit by Member of the Executive Council, 7.30 p.m.——LIVERPOOL BRANCH : Lecture Theatre Service Centre, 9, Whitechapel, Liverpool, " The Dorman Miniature Circuit Breaker," H. W. Wolff, 7.30 p.m.

Mon., Dec. 15th.—N.W. LONDON BRANCH : Prince of Wales Hotel, Kingsbury, " The Maintenance of Electric Lifts," 8 p.m.

Mon., Dec. 15th.—BOURNEMOUTH BRANCH : Grand Hotel, Firvale Road, Bournemouth, Lecturettes by Members, 8.15 p.m.

Tues., Dec. 16th.—LONDON NATIONAL LECTURE : Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, " Progress in Electric Lighting," W. J. Jones, 6.30 p.m.

Wed., Dec. 17th.—COVENTRY BRANCH : Technical College, Coventry, " Some Electro-Mechanical Equipment for Machine Tools," C. Haywood, 7.15 p.m.——S.W. LONDON BRANCH : The Guild House, 32, Worple Road, Wimbledon, " Responsibility of a Supervisor," W. J. Spencer, 8.15 p.m.——MANCHESTER BRANCH : Engineers Club, Albert Square, Manchester, Chairman's Night, 7.30 p.m.

Thurs., Dec. 18th.—LUTON BRANCH : George Hotel, Luton, " Diesel Electric Generation," 8 p.m.

CLEVELAND INSTITUTION OF ENGINEERS

Mon., Dec. 15th.—Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, " Productivity Team's Impressions of American Rolling Mills," 6.30 p.m.

HULL CHEMICAL AND ENGINEERING SOCIETY

Tues., Dec. 16th.—Church Institute, Albion Street, Hull, " Some Aspects of Industrial Toxicology," E. E. Connolly, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Tues., Dec. 16th.—LIVERPOOL CENTRE : Merseyside and N. Wales Electricity Board's Service Centre, Whitechapel, Liverpool, 1, " The Eye, Brightness and Illuminating Engineering," W. S. Stiles, 6 p.m.——CARDIFF CENTRE : S. Wales Electricity Board, Cardiff, " Floodlighting," R. O. Ackerley, 5.45 p.m.

Wed., Dec. 17th.—SWANSEA GROUP : Minor Hall, Y.M.C.A., Swansea, " Floodlighting," R. O. Ackerley, 6 p.m.——TEESSIDE GROUP : Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, " Brightness Engineering," W. Robinson, 6.30 p.m.

Thurs., Dec. 18th.—GLOUCESTER AND CHELTENHAM CENTRE : Cadena Cafe, High Street, Cheltenham, " The Equipment and Functions of an Illumination Laboratory," H. F. Stephenson, 6.15 p.m.

Fri., Dec. 19th.—BIRMINGHAM CENTRE : Regent House, St. Philips' Place, Colmore Row, Birmingham, " Fashion and Creative Photography in Advertising," J. Short, 6 p.m.

INCORPORATED PLANT ENGINEERS

Tues., Dec. 16th.—HERTFORDSHIRE DISCUSSION GROUP : Peahen Hotel, St. Albans, " Oil Firing : Oil Burners and Other Applications," G. A. Foster, 7.30 p.m.

Wed., Dec. 17th.—KENT BRANCH : Bull Hotel, Rochester, " Planned Maintenance for the Plant Engineer," F. L. Griffiths, 7 p.m.

Thurs., Dec. 18th.—BLACKBURN BRANCH : Chamber of Commerce, Richmond Terrace, Blackburn, " Lubrication," 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., Dec. 16th.—BIRMINGHAM BRANCH : Grand Hotel, Colmore Row, Birmingham, " Shrinkage in Non-Ferrous Sand Castings and its Control," R. A. Skinner.

INSTITUTE OF FUEL

Wed., Dec. 17th.—Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, " Removal of Sulphur Oxides from Flue Gases," R. Llewellyn Rees ; " Recovery of Sulphur from Flue Gas by the Use of Ammonia," S. R. Craxford, A. Poll and W. J. S. Walker ; " Survey of the Concentration of Sulphur Dioxide in the Air of South-West London—A First Appraisal of Results," S. H. Richards, 6 p.m.

INSTITUTE OF NAVIGATION

Fri., Dec. 19th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, " Navigation on Land," R. A. Bagnold, 5 p.m.

INSTITUTE OF REFRIGERATION

Tues., Dec. 16th.—Institution of Mechanical Engineers, Storeys Gate, St. James's Park, London, S.W.1, " Factors Governing the Design of Chambers for Very Low Temperatures, Including those Operating Under Cyclical Temperature Conditions," S. H. W. Richards, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Wed., Dec. 17th.—N.W. CENTRE : Victoria Hotel, Wigan " Vehicle Development in the Past Decade," W. C. Wilson, 7.30 p.m.

Thurs., Dec. 18th.—LONDON CENTRE : Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, " Vacuum and Air Brakes," S. H. Edge, 6.30 p.m.——N.E. CENTRE : Hotel Metropole, Leeds, A Selection of Technical Films, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

To-day, Dec. 12th.—GRADUATES' AND STUDENTS' SECTION : Caxton Hall, Westminster, London, S.W.1, " The Production of Chlorine," C. R. Black, 6.30 p.m.

Wed., Dec. 17th.—MIDLANDS CENTRE : The University, Edmund Street, Birmingham, A Debate : " This House Considers that the Chemical Engineer has no Place in Industry," Proposed E. R. Walgrove, Seconded S. W. F. Dines, Opposed F. Morton, Seconded D. C. Freshwater, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

To-day, Dec. 12th.—YORKSHIRE ASSOCIATION : Royal Victoria Station Hotel, Sheffield, " Economic Use of Heavy Earth-Moving Equipments and Field Maintenance Thereof," B. J. Meighan, 7 p.m.

Tues., Dec. 16th.—UNWIN LECTURE : Great George Street, Westminster, London, S.W.1, " The Development and Functions of the Research Department of the Railway Executive," T. M. Herbert, 5.30 p.m.

Wed., Dec. 17th.—MIDLANDS ASSOCIATION : Birmingham and Midland Institute, Paradise Street, Birmingham, " Factors Affecting the Location, Design and Operation of a Modern Coal-fired Power Station," S. W. Lawton, 6.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Dec. 15th.—RADIO SECTION : Savoy Place, London, W.C.2, Discussion on " How to Plan a Radio Project," opened by J. Thompson, 5.30 p.m.

Tues., Dec. 16th.—LONDON STUDENTS' SECTION : Savoy Place, London, W.C.2, " Modern Transformer Construction," A. J. W. Beckey, 7 p.m.——S.W. SCOTLAND SUB-CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, " Microwave Radio Links," A. T. Starr, 7 p.m.

Wed., Dec. 17th.—SUPPLY SECTION : Savoy Place, London, W.C.2, " Uses of Earthed Signal Conductors on Transmission Circuits," W. Casson, 5.30 p.m.——S.E. SCOTLAND SUB-CENTRE : Heriot-Watt College, Edinburgh, " Microwave Radio Links," A. T. Starr, 7 p.m.——S. MIDLAND CENTRE : Birmingham and Midland Institute, Paradise Street, Birmingham, " Factors Affecting the Location, Design and Operation of a Modern Coal-fired Power Station," F. W. Lawton, 6.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Dec. 16th.—39, Elmbank Crescent, Glasgow, C.2, " Textile Machinery," K. S. Laurie, 6.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Dec. 17th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, " Recent Developments in the Use of Rubber in Railway Engineering," S. W. Marsh, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Mon., Dec. 15th.—SCOTTISH A.D. CENTRE : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, " Commercial Vehicles Problems, Their Investigation and Solution," G. H. Lee, 7.30 p.m.

Tues., Dec. 16th.—MIDLAND BRANCH : College of Technology and Arts, Eastlands, Rugby, " The Art of the Practical Engineer," Sir David Pye, 6.15 p.m.——N.W. A.D. CENTRE : Engineers Club, Albert Square, Manchester, " Engineering Changes," H. Drew, 7.15 p.m.

Wed., Dec. 17th.—MIDLAND BRANCH : Birmingham and Midland Institute, Paradise Street, Birmingham, " Factors Affecting the Location, Design and Operation of a Modern Coal-fired Power Station," F. W. Lawton, 6.30 p.m.——SOUTHERN BRANCH : The University, Southampton, " Powered Flying Controls," F. J. Bradbury and S. M. Parker, 7 p.m.——YORKSHIRE BRANCH : Grand Hotel, Sheffield, " Economic Plant Sizes and Boiler-Set Groupings on the British Grid," B. Donkin and P. H. Margen, 6.30 p.m.

Fri., Dec. 19th.—GENERAL MEETING : Storey's Gate, St. James's Park, London, S.W.1, " Contemporary Methods of Watch Production," R. A. Fell and P. Indermuhle, 5.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Dec. 12th.—EASTERN COUNTIES SECTION : Public Library, Ipswich, " The World's Largest Walking Dragline—Its Manufacture and Assembly," C. Mc. L. Cameron and F. Clifton, 7.30 p.m.

Mon., Dec. 15th.—MANCHESTER SECTION : Reynolds Hall, College of Technology, Sackville Street, Manchester, 1, " Materials Handling," L. W. Bailey, 7.15 p.m.——N.E. SECTION : N. of England Institute of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne, " The Development of Engineering Metrology," F. H. Rolt, 7 p.m.

Tues., Dec. 16th.—OXFORD SUB-SECTION : Morris Motors, Ltd., Apprentice School, Hollow Way, Cowley, Oxford, " Materials Handling," E. Williamson, 7.15 p.m.

Wed., Dec. 17th.—BIRMINGHAM SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, " The Advent of Automatic Transfer Machines and Mechanisms," F. G. Woollard, 7 p.m.——COVENTRY SECTION : Church House, Church Street, Rugby, " Electronics as an Aid to Productivity," J. A. Stokes, 7 p.m.——LINCOLN SECTION : Ruston and Hornsby, Ltd., Boultham Works, Lincoln, Film Show and Discussion on Cutting Tools and Tungsten Carbide, 7.30 p.m.——WESTERN SECTION : Beaufort Room, Grand Hotel, Bristol, 1, " New Techniques in Aircraft Production," L. R. Benton, 7.15 p.m.

Thurs., Dec. 18th.—SOUTHERN SECTION : Polygon Hotel, Southampton, " Some Interesting Set-Ups on Modern Machine Tools," R. C. Fenton, 7 p.m.

Fri., Dec. 19th.—NORWICH SUB-SECTION : Suckling Hall, St. Andrew's Plain, Norwich, " Planning for 5 or 250,000 Parts," R. E. Copelin, 7.40 p.m.

INSTITUTION OF SANITARY ENGINEERS

Tues., Dec. 16th.—Caxton Hall, Westminster, London, S.W.1, " An Introduction to Prestressed Concrete and its Application to Sanitary Engineering," R. C. Blyth, 6 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Tues., Dec. 16th.—SCOTTISH BRANCH : Ca'doro Restaurant, Union Street, Glasgow, " Structural Design of Cranes," J. H. Huntley, 6 p.m.

Wed., Dec. 17th.—YORKSHIRE BRANCH : The University, Leeds, " Unusual Design for a Large Constructional Shop," F. R. Bullen, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Dec. 12th.—Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, Presidential Address, " The Air and the Future," F. R. Banks, 7.30 p.m.

Fri., Dec. 12th.—Townsend House, Greycoat Place, London, S.W.1, " Some Everyday Problems of Running a Car," E. E. Burrage, 7 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Dec. 12th.—Literary and Philosophical Society's Lecture Theatre, Newcastle upon Tyne, " The Application of Research to the Gas Turbine," Hayne Constant, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Dec. 16th.—GRADUATES' AND STUDENTS' SECTION : 4, Hamilton Place, London, W.1, " An Introduction to Aircraft Vibration," D. J. Mead, 7.30 p.m.

Thurs., Dec. 18th.—Chemistry Lecture Theatre, University College, Gower Street, London, W.C.1, Full Day Discussion on Fatigue.

SHEFFIELD SOCIETY OF ENGINEERS AND METALLURGISTS

Mon., Dec. 15th.—The University Building, St. George's Square, Sheffield, Annual General Meeting, " Making it Work," W. A. Tuplin, 7.30 p.m.

WOMEN'S ENGINEERING SOCIETY

Wed., Dec. 17th.—LONDON BRANCH : 35, Grosvenor Place, London, S.W.1, " Water Treatment," Miss E. M. Collin, 6.30 p.m.